POWER

Volume 60 New York, July 8, 1924 *No.* 2

Approaching the Imponderable

THERE was a story, current years ago, of the astonishment of an Indian guide who was dispatched with a message written upon a piece of wood at the ability of the white man to "make a chip talk."

Less than ninety years ago the first telegraph began writing out its messages by dots and dashes on a strip of paper. Instead of the physical passage of a courier from point to point to carry the material writing, a mysterious current conveyed the message letter by letter, instantaneously, wherever a wire could be stretched.

And then it developed that the recording of the message upon the paper tape was unnecessary. Each letter had a rhythm, a distinctive character which the intangible sound wave registered upon the ear of the operator and he found that he could write it down as it came in without referring to the tape, and the register was discarded for the sounder, the practicability of which would probably have been long in being recognized without the intermediate step of the tape receiver.

And then some fifty years later it was discovered that the wire would transmit the rapid vibrations that constitute sound as well as it would the slower pulsations of the operator's fingers, that speech could be transmitted intact instead of being spelled out into its constituent letters; and the mandate, "Don't travel; telephone!" went forth.

And then it was discovered that a disturbance set up in the ether could be picked up at a distance, without any transmitting wire, and the radio was born. And one may sit in his library and extract from the Hertzian waves with which the air is filled, the form of entertainment, edification or instruction which most appeals to his needs and mood.

And now comes news of recognizable photographs transmitted over miles of wire, with its promise, or at least suggestion, of the realization of that possibility of seeing at a distance the thought of which came with the successful transmission of the human voice.

The first steam engines were ponderous affairs, with great cylinders, slow-running pistons, walking-beams, and great gears to transmit their power. High speed and pressure reduced the ponderousness of the prime mover, but we were still dependent upon the gears and shafting, ropes and belts for the transmission and distribution of their power.

Then it was discovered that there existed between the poles of an electromagnet an invisible, imponderable something that opposed resistance to the passage of a conductor, and that in a conductor forced through it was generated an electric current

And then it was found that if this current were run through a device similar to that which generated it, it would convert that device into a motor. The ponderous mechanical drive gave place to the intangible invisible current and we talked kilowatts instead of horsepower.

And then, instead of pushing a piston back and forth we blew a bladed wheel around at a velocity of as many feet per second as the piston had made per minute and reduced in the turbine the weight and space and cost per kilowatt, with better efficiencies.

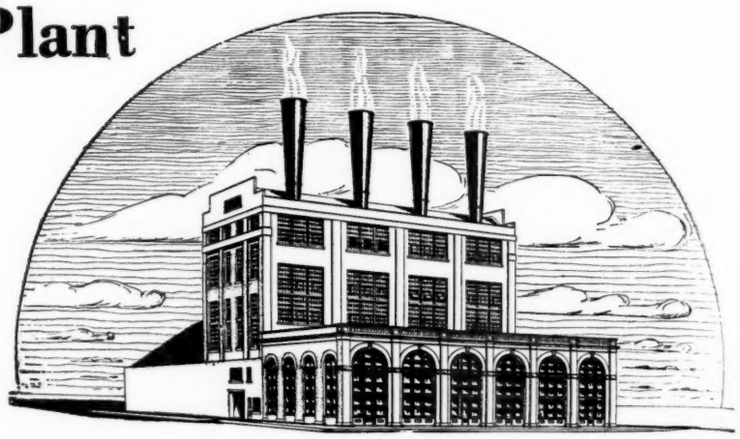
And now they are dissecting the atom and find it to be a minute solar system, upon the number and arrangement of the constituents of which the identity of the substance which they compose depends.

And these components are said to consist of nothing more than electric charges or centers of stress.

Somebody once said "Give me matter and energy and I will create a universe." It begins to look as though all that he needed was energy.

F. R. Low

Central Heating Plant At Grand Rapids



A high-pressure central heating plant in which exhaust steam and steam bled from non-condensing turbo-generator is utilized for stage feed water heating and for supply to heating mains at three different pressures. Boiler pressure is 350 lb. gage, 200 deg. F. superheat. Furnace air preheating, low-pressure economizers, venturi stacks.

THE initial unit of a central heating plant at Grand Rapids, Michigan, has been completed and was in operation during the past season. The second unit is under construction. The ultimate plant will have four boilers and two generating units, with a heating capacity ranging from 600,000 to 1,000,000 sq.ft. of required direct radiation and a power rating of 4,500 kw. This is one of the new plants of the Consumers Power Co., whose headquarters are at Jackson, Mich., and in its design the engineering staff of the company has gone to unusual lengths in incorporating refinements to assure the highest feasible operating economy consistent with reliable heating and minimum total cost.

The new station is on the site of the old Fulton Street plant installed nearly forty years ago by the Grand Rapids Edison Co. It will serve a territory in the business center within a radius of one-half mile from the plant, supplying steam for heating, cooking and laundry use. The distribution system has been entirely rebuilt, the oldest main in service having been installed in 1916, and nearly all of the mains within the past three years.

Uses for Bled Steam

For low-pressure distribution, exhaust steam from the one turbo-generating unit now installed is available at 2 to 8 lb. pressure, and also service steam at 50 and 100 lb. can be bled from the turbine after the power has been extracted from the initial conditions at the throttle down to these points. This bled steam is also available to preheat the feed water in closed heaters, adding to its temperature after it has come from low-pressure cast-iron economizers. The hot air at the top of the building containing the heat radiated from the machinery and equipment in the plant is drawn down through an air duct by the forced-draft fan and delivered to the boiler furnaces. Between the discharge of the fan and the furnace the air temperature is to be increased by steam from the first- and third-stage heaters, at pressures of 5 and 100 lb. respectively, so that its final temperature approximates 300 deg. F. Conservation of the heat in the blowoff water and the method employed to desuperheat the steam are features in the plant differing from usual practice.

The headpiece is a drawing showing how the plant will look eventually. The low structure in the foreground is the turbine room and the higher building at the rear, the boiler house. The turbine room is the old original engine room of the Grand Rapids Edison Co. With the plant located in the business district, the area of the site is limited with two railway sidings each long enough for two cars per switch. Owing to the limited floor area it was necessary to build a high boiler room and to provide facilities for unloading and storing coal rapidly.

Two of the four boilers to be installed are now in service, each being of the cross-drum type, containing 5,926 sq.ft. of heating surface. The operating pressure is 350 lb. gage, and the superheat 200 deg. F., giving a final steam temperature of 636 deg. The boiler setting is unusually high, the bottom of the lower tube header being 14 ft. above the floor and the bottom of the rear tube header 19 ft. 4 in. Bridge-wall water backs of the radiant superheater type connected into the boiler circulation have been installed and provision has been made for side-wall water backs. The headers which now extend to the rear water backs are in place and may be tapped later for the tubes to form the side-wall water backs. When this plan is completed, practically the entire area of the furnace walls will be converted into heat-transfer surface.

The superheater is of the integral type, located above the first and second passes. Directly above each boiler is a double-bank cast-iron economizer baffled vertically for three passes. Nothwithstanding the poor annual load factor, placed at about 20 per cent for the heating business, the use of economizers was considered a profitable investment, as with the arrangement of the plant no steam was available for heating the feed water except that which could be sold for heating purposes. It was decided to operate them under the pressure of the heating main—that is, at 2 to 8 lb. gage—and let them steam into the mains through a steam separating drum, in much the same way as a low-pressure waste-heat boiler would function.

Each boiler has an eight-retort underfeed stoker, a stoker of large proportions being desirable since operation as high as 400 to 450 per cent of rating had been planned.

Coal comes from the mines crushed in sizes 1¼ in. and under. From the cars it is unloaded into a track hopper and transferred by a reciprocating feeder to a belt conveyor to be passed over a weightometer and delivered to the bottom run of a pivoted bucket conveyor making the circuit of the boiler house. On the top run delivery is made into the overhead bunkers of steel plate, concrete lined, parabolic in cross-section and of 400 tons capacity.

By means of a telescopic spout coal from the top run

of the pivoted bucket conveyor may be delivered into the outdoor storage at the rear of the boiler room. This space is to be inclosed by concrete walls, giving a capacity of approximately 4,000 tons. When reclaiming from storage, much of the coal will pass by gravity to the lower run of the continuous bucket conveyor in chutes passing through the basement wall at an incline approximately 45 deg. When the coal in storage is low, hand shoveling or a power dragline will be necessary. The capacity of the system is 30 tons per hour, and with coal coming in at a normal rate, only part of one man's time is required to transfer it to the bunkers or yard storage.

From the overhead bunkers the coal passes through rack and pinion gates, operated by chains from the boiler-room floor, into steel-plate distributing chutes and spreaders to the stoker hoppers. Through the double-roll clinker grinders of the stoker, the ashes discharge into a concrete pit.

Waste Heat Recovered

Each boiler has its individual forced-draft fan. Each fan draws its supply of air from the pipe tunnel directly underneath, which has a duct connection with the economizer room above the boilers. Through openings in the economizer floor the hot air from the boiler room is drawn through the air duct by the fan suction and much of the radiated heat from the boilers and the economizers is recovered in the air delivered to the boiler furnaces. If more air is required than can be obtained in this way, louver dampers in the side of the air duct are opened and outdoor air is drawn in and heated by means of indirect radiation. For this indirect radiation water from the blowoff tank will be utilized; this blowoff tank will receive all waste water that still contains some heat.

During average winter weather the indirect radiation raises the air temperature to about 50 deg. F., and the radiated heat losses of the station will add another 30 deg., so that air of at least 80 deg. temperature passes through the fan. Before delivery to the windbox of the stoker the air will pass through two stages of pipe-coil preheating, the first supplied with low-pressure exhaust steam or condensation and the second with bled steam at 100 lb. pressure from the turbine bleeder connection. These preheating arrangements are expected to give a final air temperature approaching 300 deg. F.

A turbine-operated induced-draft fan supplies each venturi stack, the air from the fans being discharged through the throat of the stack by means of a special-shaped nozzle. The air requirements in cubic feet per minute to operate the stack range from 14,500 to 33,000 for boiler ratings from 150 to 400 per cent. The fan turbine takes steam at boiler pressure and exhausts into the low-pressure heating main

As the condensation from the services in the district is not brought back to the plant, the makeup approaches 100 per cent. The primary source is the Grand River, although an emergency connection is made to the city water supply. Considering the high ratings at which the boilers operate, it was essential to soften and purify the water. This is done by an intermittent or batch system in concrete tanks built into the foundations of the boiler house, as indicated in Fig. 1. Caustic soda and lime are the chemicals used. A treatment tank for each boiler is provided, and in addition there is a settling basin and clearwell. As the total length of the settling basin and clearwell is nearly 200 ft. and the water ordinarily takes more than twenty-four hours to pass through to the economizer pump, filters were not considered necessary. The treatment tanks have been proportioned so that a minimum of ten hours is allowed for filling, reaction and settling.

There are two economizer pumps which draw from the clearwell and force the water to the expansion tanks above the economizers; from these tanks it flows to the economizers, where it is heated to approximately 220 deg. F. The expansion tanks above the economizers steam into the low-pressure exhaust main. The water returns through the first-stage boiler-feed heater, taking steam from the low-pressure exhaust main at 2 to 8 lb. pressure, to the suction of the boiler-feed pumps, one being motor-driven and the other turbine-driven, the choice in their use depending upon the exhaust-steam requirements. Either of these pumps forces the water through two closed heaters in series to the boilers at a temperature approximating 300 deg. F. The first heater encountered is the second-stage boiler-feed heater and the next the third-stage heater, both taking steam bled from the main turbine at 50 and 100 lb. respectively. Bled steam at these pressures is also available for commercial service. As any after-reactions from the cold-process softening are expected to take place in the economizer and the heaters, the latter may be bypassed to facilitate the removal of the soft slime collecting in the tubes.

As the sodium sulphate solution resulting from the feed-water treatment tends to cause boiler-water concentration, so that frequent blow-downs are necessary, a special blowoff tank is to be provided in the final installation to conserve the heat in the water. This will replace the present arrangement of blowing into a concrete basin and from there to the sewer. The tank will receive all clean drips and hot-water discharges. A portion of the supply in the tank will pass through the Vento coils preheating the combustion air, while the sludge that settles to the bottom of the tank will be blown off to the sewer. It is proposed to use a tank equipped with an atmospheric relief valve.

Unique Method of Desuperheating

To obtain desuperheated steam for service and air preheating, an interesting method has been introduced in connection with the closed heaters. The steam bled from the turbine is admitted to the underside of the heater through a pipe of large diameter. Condensation dropping from the heater tubes through the incoming steam will flash into vapor and in doing so will absorb the superheat so that saturated steam may be drawn off through an opening at the top of the heater shell. It will be seen that the system is automatic and requires no attention. Condensation from the heaters is trapped and, in the case of the third-stage heater, passes and flashes into the hotwell of the second-stage heater and thence to the low-pressure main or through the first stage of the air preheater to the clearwell. The condensation from the heaters is drained into the heating mains to remove any superheat that may be left in the steam. As a safeguard, separators and drains at various points in the line are provided to relieve the main of any excess water. These drains are collected in a receiving tank, and the water is pumped back into the clearwell

It should have been explained that the boiler-feed piping is in duplicate. The main boiler-feed header

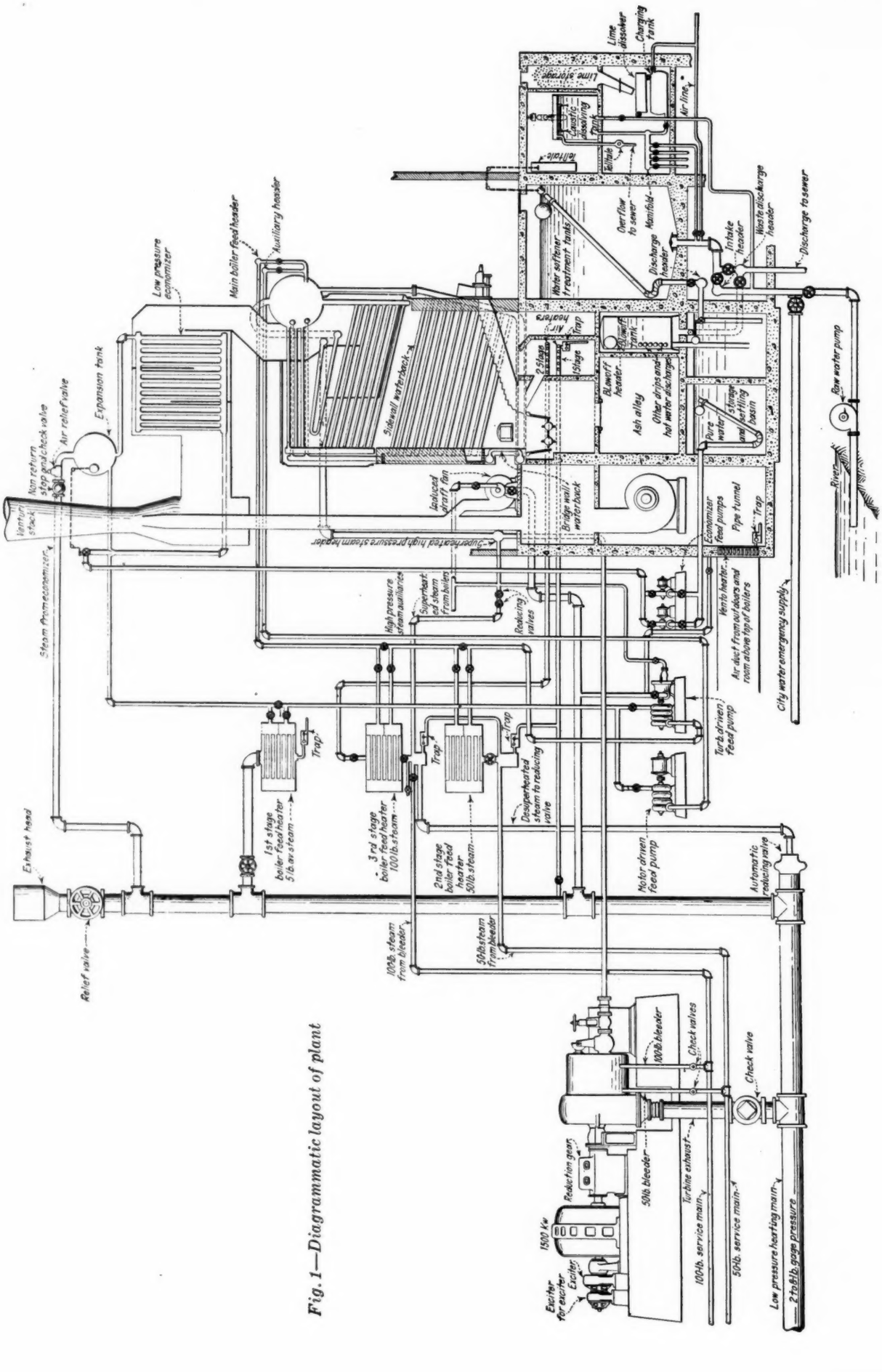


Fig. 1—Diagrammatic layout of plant

takes in the second and third heaters and is provided with automatic control at the boilers. An indicating registering and curve-drawing venturi meter is located on the branch to each boiler. The auxiliary line passes directly to the boilers from the pumps and is arranged for hand control. All-steel extra-heavy construction is employed between the pumps and the boilers.

One of the notable features of the boiler room is the simplicity of the high-pressure piping, its small diameters and the high steam velocities employed. From adjacent boilers the two 6-in. outlets unite through a Y-shaped cast-steel fitting into an 8-in. pipe leading to a short manifold. From here a 5-in. line supplies the 1,500-kw. turbo-generator now installed and provision is made for a crossover connection with the pair of boilers now going in. From this cross-line steam is driven for two turbine-driven fans and one turbine-driven boiler-feed pump. Sargol welded joint construction is employed in all high-pressure superheated steam lines over 4 in. in diameter.

Features of Non-Condensing Unit

In the turbine room the interesting feature is the non-condensing unit of 1,500-kw. capacity. Under steam conditions of 350 lb. gage, 200 deg. F. superheat and a back pressure of 5 lb. the guaranteed water rates per kilowatt-hour are at full load, 23.5 lb.; at three-quarter load, 25 lb.; and at one-half load, 28 lb. Even under the favorable steam conditions this is exceptional economy for a non-condensing turbine. The machine has eleven stages, the first being a Curtis wheel with double velocity rows of buckets and the other ten stages of the Rateau type. The operating speed of the turbine is 3,600 r.p.m., which is reduced by a herringbone reduction gear to 900 r.p.m. for the generator, a 7,500-volt 30-cycle three-phase machine. Mention has been made of the two bleeder connections on intermediate stages for steam extraction at 50 and 100 lb. pressure. In addition to the usual speed and emergency overspeed governors, the turbine has special automatic governors to control the steam flow to it so as to maintain the desired back pressure on the low-pressure heating mains. A hand-controlled gridiron valve is provided to regulate the pressure on the 100-lb. bleeder line.

One of the advantages of the station is the electrical interconnection with the system of the Consumers Power Co. so that the turbine may be operated at any rating up to its maximum capacity to balance the exhaust-steam demand. When this demand is in excess of the turbine capacity, the steam-driven auxiliaries are used in preference to those operated by motor. These motors are of the constant-speed induction type except those driving the forced- and induced-draft fans, which are slip-ring induction motors to permit a speed variation of 50 per cent. With the special forced- and induced-draft arrangement and the hydraulic stoker drives the use of direct-current power was avoided, although it was available at the plant. The 440-volt three-phase 30-cycle current used by the motors is supplied through a bank of station transformers.

Induced draft for the stack is automatically regulated, while the forced draft and the coal feed are controlled by hand. A full complement of instruments for measuring coal, feed water, steam flow, drafts, steam, gas temperatures, etc., are provided to give a complete record of the daily performance. Such data are not available at the present writing, as the plant is still in the construction period, so that it is too soon to expect representative results.

For the design credit is to be given to the engineering staff of the Commonwealth Power Corporation, the holding company, of which H. F. Eddy is mechanical engineer.

DATA ON PRINCIPAL EQUIPMENT AT FULTON STREET HEATING PLANT, GRAND RAPIDS, MICH.

The first installation of this plant has been completed and was operated during the 1923-24 heating season. The second and final installation is now in the cours of construction and will be completed in time for the 1924-25 heating season Data here given are for the finished plant.

GENERAL

Location	Grand Rapids, Mich.
Character of service	Heat and power
Capacity, heating	600,000 to 1,000,000 sq.ft. of required direct radiation surface.
Capacity, power	4,500 kw. at 80 per cent power factor, 30-cycle, 7,500 volt, a.c., 3-phase.
Boiler house, ft.	49x100
Turbine room, ft.	51x100
Width of firing aisle, ft.	14.5
General contractor	Benjamin Douglas Co., Ann Arbor, Mich.

BOILERS AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.
Type	Cross-drum, water-tube
Number installed	4
Steam-making surface per boiler, sq.ft.	5,926
Ratio of steam-making surface to projected grate area	27.4 to 1
Furnace volume, cu.ft.	3,300
Sq.ft. of steam making surface per cu.ft. of furnace volume	1.8
Cu.ft. of furnace volume per sq.ft. of projected grate area	15.2
Arrangement of tubes	10 high and 23 wide
Size of tubes	4 in. diam., 20 ft. long, No. 7 gage
Boiler pressure, lb. gage	350
Type of superheater	Babcock & Wilcox patent
Manufacturer	Babcock & Wilcox Co.
Location	Between 10th and 11th row
Superheat, deg. F.	200

WATER BACKS

Manufacturer	Power Specialty Co.
Number per boiler	One, in back wall of setting above clinker grinder rolls
Type	Foster radiant, heat superheater design
Heating surface, sq.ft. per boiler	40

FUEL

Kind	West Virginia and Kentucky
Average B.t.u.	13,750

STOKERS

Manufacturer	American Engineering Co.
Type	Taylor F. H. H. 7, eight-retort, 33-tuyere, hydraulic drive and double-roll ash discharge
Width of stoker	13 ft. 11½ in.
Depth of stoker	15 ft. 6 7/16 in.
Projected and active grate area, sq.ft.	216.8

STOKER DRIVE

Each stoker driven by two type P-12 Hele-Shaw pumps driven by a direct connected motor. Any retort may be shut down for repair to external driving mechanism without affecting the operation of the others. Coal feed operated by hand. Ash discharge rolls operated by hydrajlic cylinder with adjustable pawls and ratchet wheel.

Combined effic.ency of furnace,boilers and economizer using 13,900 B.t.u. coal.

Rating	150	200	250	300	400
Efficiency, per cent	81.5	83	83	82	79.5

ECONOMIZERS

Manufacturer	Green Fuel Economizer Co.
Type	Green's improved patented "M" baffled type with cast-iron tubes arranged in double banks of 120 tubes each.
Heat-absorbing surface, sq.ft.	3,900
Per cent of heat absorbing surface in economizer to heating surface in boiler	65

Performance:

Rating	Hp.	Feed Temp., Deg. F.	Gas Temp., Deg. F.	Lb. Gas per Hr.	Lb. Water per Hr.	Rise, Deg. F.	Final Gas Temp., Deg. F.	Draft Loss, In.
100	593	75	520	32,000	19,200	108	210	0.15
150	895	75	570	48,000	28,800	105	270	0.22
200	1,186	75	625	66,000	38,400	108	315	0.30
250	1,485	75	680	86,000	48,000	116	360	0.50
300	1,779	75	740	110,000	57,600	130	410	0.75
400	2,372	75	775	150,000	77,000	130	450	1.00

One economizer installed above each boiler.

DATA ON PRINCIPAL EQUIPMENT AT FULTON STREET HEATING PLANT, GRAND RAPIDS (Concluded)

SOOT BLOWERS IN ECONOMIZERS

Manufacturer	Diamond Power Specialty Co.
Type	Valve-in-head, hand-operated, using steam for blowing
Number per unit	Six 1½-in. heads and two 2-in. heads
Piping	All joints on high-pressure steam piping from superheaters to turbine are Sargol weld connected, all other high-pressure piping Vanstone connected. The 22-in. low-pressure heating main is Vanstone connected

BOILER-CONTROL SYSTEM

Forced-Draft Fans:

Manufacturer	Green Fuel Economizer Co.
Number of fans	4
Capacity of each, cu.ft. per min. static head 6 in.	65,000
Drive	100 hp. 870 r.p.m. variable-speed motor. Speed reduction to 435 r.p.m. by hand-operated drum controllers
Type	No. 6½ special type R. P. Green forced-draft radial flow

Induced-Draft Fan for injection of cold air to Venturi stacks:

Manufacturer	Green Fuel Economizer Co.
Number of fans	2
Capacity, cu.ft. per min. static head 24 in.	35,000
Drive	125 hp. 1,365 r.p.m. noncondensing turbines operated at 325 lb. gage, 200 deg. superheat. Turbine exhausts into heating main at 5 lb. back pressure
Type	No. 4 Green's, type S. A.

Induced-Draft Fans for handling hot flue gases:

Manufacturer	Green Fuel Economizer Co.
Number of fans	2

Boiler Rating	Capacity, Cu.Ft. per Min.	Temp., Deg. F.	Draft, In. Water
150	15,600	270	0.75
250	31,000	360	1.40
300	42,500	410	2.25
400	63,000	450	3.50

Drive	100 hp., 600 r.p.m., G. E. motor
Type	Green No. 6 S. A. D.

STACKS

First installation:

Manufacturer	Schutte & Koerting
Number of stacks	2
Type of stack	Prat patent, steel unlined, self-supporting venturi stack

Performance:

Boiler Rating	Lb. Gas per B.Hp.-Hr.	Air Required in C. F. M. To Operate Stack	Static Press. at Nozzle Discharge, In. of Water	Hp. at Fan
150	53.8	14,500	1.4	6.7
250	56.9	20,000	4.6	24.4
300	60.7	23,700	7.7	46.6
400	62.0	33,000	14.0	120.0

Induced draft fan discharge is cross-connected between the venturi nozzles in the two stacks. Forced-draft fans may also be used to aid the induced draft. This is accomplished by the use of connecting ducts and dampers.

Height above firing aisle, ft.	85
Inside diameter at top, ft.	8
Inside diameter at throat	3 ft. 11 in.
Boilers per stack	1

Second installation:

Manufacturer	Wickes Boiler Co.
Number of stacks	2
Type of stack	Steel, self-supporting, unlined
Height above firing aisle, ft.	85
Inside diameter at top, ft.	8
Inside diameter at induced draft fan, ft.	5
Boilers per stack	1

BOILER-FEED PUMPS

Manufacturer	Union Steam Pump Co.
Number of pumps	1 turbine and 1 motor-driven
Motor-driven pump:	
Type	Class U, 4-in. horizontal, six-stage, centrifugal
Capacity, g.p.m. against 900 ft. head	300
Drive	125 hp., G. E. motor, direct connected
Turbine-driven pump:	
Type	Class U, 3 in. horizontal, six-stage centrifugal
Capacity, g.p.m. against 900 ft. head	300
Drive	120 hp., G. E. turbine

ECONOMIZER FEED PUMPS

Manufacturer	Union Steam Pump Co.
Number of pumps	2
Type	Class B. L. 3 in. horizontal, single-stage, centrifugal
Capacity, g.p.m. against 125 ft. head	200
Drive	15 hp., G. E. turbine

CONDENSATE PUMP

Manufacturer	Union Steam Pump Co.
Type	7½ x 5 x 8 in. horizontal duplex double-acting
Capacity, g.p.m.	50

FEED-WATER HEATERS

Manufacturer	Ross Heater & Mfg. Co.
Number of heaters	3:1 each for high, intermediate and low pressure
Type	Closed, floating head
Location	High-pressure is on 100 lb. bleeder from turbine; intermediate pressure is on 50 lb. bleeder from turbine; low pressure is on 8 lb. heating line

COAL HANDLING

Manufacturer	Link-Belt Co.
Type	"Peck Carrier"
Capacity, tons	30
Bunker, capacity and type	Parabolic, steel, concrete lined, 400 tons
Coal distributed in bunker	Adjustable trip for buckets of carrier
Coal distributed to storage	Chute and adjustable grain spout from carrier
Coal to carrier	Coal dumped from cars in track hopper, from hopper to belt conveyor by a reciprocating feeder, along belt conveyor and over a Merrick weightometer, belt conveyor delivers to the Peck carrier
Storage to carrier	Chutes through boiler house wall deliver coal from storage to carrier. Feed through chutes either by gravity, hand shoveling or power drag line

ASH HANDLING

Concrete pits below the double roll ash discharge of stoker. These dump directly by gravity into trucks driven below boiler house at street level.

Ash storage per boiler, cu.yd.	17
Gates per boiler	3 hand-operated, 2 ft. x 2 ft.
Ashes handled by truck	

MAIN GENERATING UNIT

Manufacturer	General Electric Co.
Type	Curtis, non-condensing
Capacity at 80 per cent power factor	1,500
Number of units	1 at present 3,000 kw. to be added
Speed, r.p.m.	Turbine 3,600 r.p.m.; generator, 900 r.p.m.
Throttle pressure and superheat	325 lb. gage, 200 deg. superheat, back pressure 2 to 8 lb.
Speed reduction	Single-reduction, double-helical type reduction gears connected to units by flexible couplings
Type of generator	1,875 kva., 3-phase, 30-cycle, 7,500-volt, 900 r.p.m.

Turbine performance at 325 lb. gage, 200 deg. superheat, 5 lb. back pressure:

Load, Kw.	Steam per Kw.-Hr.
750	28
1,125	25
1,500	23.5

AIR COMPRESSOR

Manufacturer	Ingersoll-Rand
Type	Class E. R.
Size, in.	10 x 10
Drive	Motor, belt connected

MISCELLANEOUS EQUIPMENT

Motors	General Electric Co.
Structural steel	Wisconsin Bridge and Iron Co. Bellfontaine Bridge Co.
Service on feed-water treatments	Cyrus Rice Co.
Venturi tubes and meters	Bryant Engineering Co.
Piping	Grinnell Co.
Steel sash	"Fenestra" Detroit Steel Products
Steel-plate work	Wickes Boiler Co.
Freight elevator	Hollister Whitney
Manlift	Phillips, Lang and Co.
Damper regulators	Coon-DeVisser Co.
Sand and gravel	Wyoming Sand & Gravel Co.
Reinforcing steel	Gabriel Steel Co.
Miscellaneous steel	Adolph Johnson Co. Grand Rapids Steel & Supply
Firebrick	A. P. Green Chas. Taylor Harbison-Walker Refractories Co.
Building face brick	McArthur by S. A. Mormon
Building common brick	Briggs Company
Boiler settings	H. A. Bishop
Temperature recorders	Taylor Instrument Co.
Pressure recorders	Brown Instrument Co.
Ventilators	Power Equipment Co.
Boiler meters	Bailey Meter Co.
Boiler trimmings and miscellaneous valves and fittings	Coon-DeVisser Co. Crane Co. Babcock & Wilcox Co. American District Steam Co. and Scully Steel Co.
Cement	Newaygo Portland Cement Co. Peninsular Portland Cement Co.
Tanks	Grand Rapids Boiler Co.
Plumbing	Fred Bauman
Roof	James Roofing Co.
Brixment	Battjes Fuel & Building Co.
Lapidolith	Robert Lake Co.

Totalizing Alternating-Current Power Loads

Methods That May Be Used To Obtain a Combined Reading of a Number of Power Loads Supplied from Alternating-Current Generators

By VICTOR H. TODD
Engineer, Westinghouse Electric & Manufacturing Company

IN THE generation and distribution of electric energy it is customary and often essential to know the total electric load in kilowatts or kilowatt-hours. This information may be required in order to limit the load on generating equipment or to figure costs or efficiency. When there is a certain place in the system that definitely divides the generating equipment from the feeder circuits and there are no shunting buses around this point, then a single wattmeter or watt-hour meter (usually polyphase) connected in at this place will record all the energy generated. Such locations are usually available in smaller installations where one set of busbars connect the generator and feeder panels, with the generators connected to one end and the feeders connected to the other end, as in Fig. 1.

Busbars are often arranged so that they may be disconnected or sectionalized at will, so that in case of a defect in any generator, bus sections or feeder, the current can be shunted around in a new path to supply the load without interruption. Thus there is often not a single place in the busbars where the total current passes in the same direction all the time, and consequently a single meter cannot be used with the ordinary simple connections. To obtain a record of the total energy in the most complete and comprehensive manner requires the installation of a wattmeter or watt-hour meter on each generator and feeder, from which the total load may be obtained by adding the various

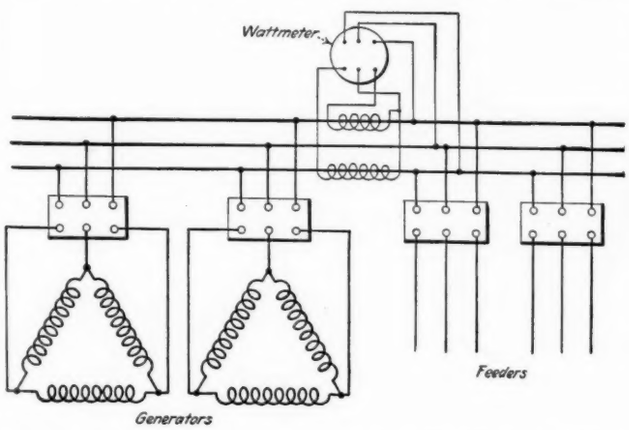


Fig. 1—Wattmeter connected in busbars to obtain total load

amounts indicated. Not only is this system expensive to install, but often the operator wishes to know at a glance just what the total load is on the generators or plant, and for this reason the following totalizing connections have been developed and are widely used.

One of the simplest cases is totalizing the power delivered by two generators, as shown in Fig. 2, where for the sake of clarity only one phase is shown metered. Both generators *A* and *B* feed the busbars *C*, the current passing through the respective current transformers *E* and *F*. It will be noticed that the secondaries of the two transformers are in parallel and both connected to wattmeter *G*, which has its voltage coil

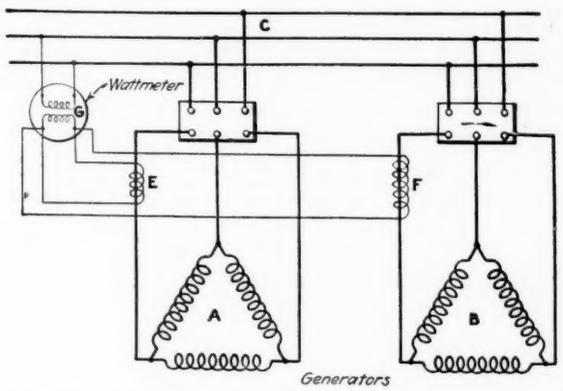


Fig. 2—Single-phase wattmeter connections using current transformers for totalizing the load on two generators

connected to the busbars. In this connection, if generator *B* should shut down, a small amount of current from transformer *E* will pass through the secondary of transformer *F* instead of the wattmeter coil, but the impedance of the secondary of transformer *F* is so high and that of the wattmeter current coil so low, that less than one per cent of the total current is diverted by transformer *F*.

It will be necessary to use a wattmeter with current coils that have a capacity equal to the sum of the secondary currents of the current transformers, or use an intermediate current transformer to reduce the total current to the capacity of the meter. For example, assume that the transformers have a ratio of 500 to 5; with two of the transformers connected to the same meter coil there will be 10 amperes flowing in it at full load. The standard meter is designed for a full load of 5 amperes in its current coils. In a watt-hour meter 10 amperes would cause the meter to run at almost double speed, but it would tend to total and record the load correctly. In the wattmeter 10 amperes would simply hold the pointer against full scale. There are two remedies. In this case the easier one would be to obtain instruments calibrated 10 amperes in the meter, equals full scale. The second method would be to interpose another transformer having a ratio 10 to 5 amperes, as in Fig. 3, so that the 10 amperes from the combined secondaries *E* and *F* passes through the primary of this additional transformer and supplying 5 amperes to the meter at full load. The calibration

now, however, must be made as if the meter were supplied with current transformers having a ratio of 1,000 to 5 rather than 500 to 5 to give the correct reading.

More Than Two Circuits Totalized

To expand these connections still further, we may totalize any number of circuits by using the same ratio current transformers and connecting their secondaries in parallel. A meter is then provided whose current rating is equal to the combined secondary currents of the current transformers, or another current transformer used whose primary rating is equal to the combined

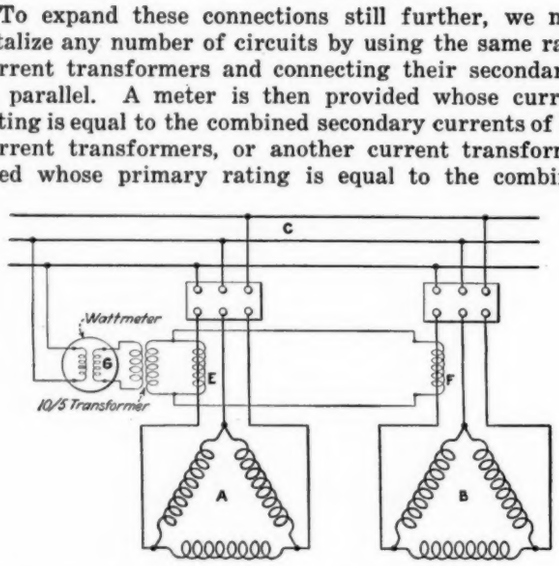


Fig. 3—Same as Fig. 2, except a third current transformer has been interposed between meter and generator transformers

secondary currents and whose secondary gives 5 amperes, thus using a standard 5-ampere meter. For example, if there are 10 circuits to totalize, using 10 current transformers with a ratio of 500 to 5 amperes, with the secondaries in parallel a total full-load current of 50 amperes would be obtained. Then a 50-ampere meter may be used or an additional current transformer having a ratio of 50 to 5, with a 5-ampere meter.

The larger the number of circuits in parallel operation, the smaller the error will be with one transformer dead; but on the other hand, if there is only one circuit alive and a number dead, then there may be considerable error due to diverted current. For this reason, if circuits will sometimes be dead, the current transformer secondaries should be provided with a double-throw switch preferably of the "heel and toe" type, which, when thrown, will first short-circuit the transformer secondary as in Fig. 4 and then disconnect it from the meter. This switch may be made automatic and operated from the circuit breaker if desired.

Instead of generator loads any connected loads may be totalized as previously described, provided they are metered with equal ratio current transformers. For instance, we may totalize all the feeders entering a station, or all the motors in a certain department, or any loads of which a total indication is desired.

Totalizing Unequal Loads

The problem of totalizing unequal loads often arises, and this may be accomplished either by special connections or by special transformers. For example, suppose it is desired to totalize a load of 500 amperes and a load of 1,000 amperes. For the first load a transformer ratio 500 to 5 amperes would be provided, the ratios must be equal to totalize. So the second circuit must be provided also with a transformer having a ratio of 100 to 1, and since the primary current is 1,000 amperes, this transformer must be 1,000 to 10 amperes. If trouble were encountered securing this capacity, two transformers 500 to 5 may be connected in parallel, both primary and secondary, thus forming a 1,000 to 10 unit which will totalize correctly with the first 500 to 5 unit. When both circuits are fully loaded, the combined secondaries will produce 15 amperes, which may be fed to a 15-ampere meter or stepped down through another 15 to 5 transformer.

Special Transformers

A special totalizing transformer is also available having one secondary and several primaries with turns according to the loads to be totalized. For example, if there are four circuits of 100, 200, 400 and 800 amperes to be totalized, a special transformer would be used having only one secondary which would supply 5 amperes when the 4 primaries were fully loaded. However, the 100-ampere winding loaded alone would produce only 0.333 ampere in the secondary, the 200-ampere winding would produce 0.666 ampere, the 400-ampere 1.333 amperes, the 800-ampere 2.666 amperes. These values, it will be noted, total to 5 amperes and the ratio of each coil is 300 to 1, or 1,500 to 5, which meets the original conditions for correct totalization.

Special Totalizing Schemes

Occasionally, there are cases where it is desired to totalize circuits of different frequencies, or loads that are far apart. For example, a station may employ 25-cycle and 60-cycle alternating current and direct current and require a total registration of all the power used. In one successful scheme the circuits are provided with watt-hour meters which close a contact every revolution or, rather, every time a certain number of

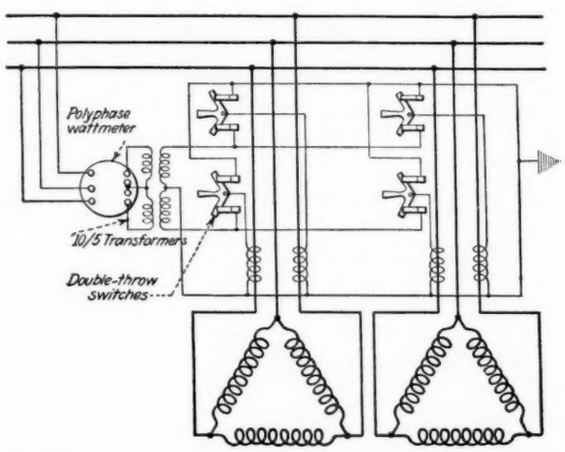


Fig. 4—Connections with double-throw switches to cut current transformers out of circuit when generator is idle

watt-hours pass, and this closing is transmitted to a master ratchet cyclometer where each impulse moves it forward a notch. If two impulses are received simultaneously, one is delayed until the first is recorded and then it, too, records.

To indicate the total-watt load, two schemes are available; one for short-distance work which balances a direct-current ammeter element against the torque of the wattmeter measuring the load. In other words, a direct current is produced in a circuit that is at all

times proportional to the watt load. Then these direct currents are paralleled and fed through a direct-current ammeter, and this ammeter indicates the total load in terms of total kilowatts. For long-distance work, as totaling the load on various substations on a long electric car line, and where leakage of the pilot direct-current would produce an error, the scheme of increasing frequency is used. In the first station a small alternating-current generator is run and its output applied to a special frequency arrangement which balances against the wattmeter element. Thus the frequency of the pilot circuit is proportional to the station load. At the next station the first frequency plus the second station load is balanced against a new frequency, so that the new frequency is proportional to the load on both stations. At each station the frequency is increased proportional to the kilowatt load, until at the final station the frequency of the pilot system is proportional to the total load on the system, and the indications on a frequency meter are marked to indicate the total load.

It is often desirable to obtain a graphic record of fluctuation of the total power load, and for this purpose the totalizing graphic wattmeter shown in Fig. 5 may be used, to totalize circuits of any capacity and frequency whether in synchronism or not. Referring to the schematic diagram in Fig. 6, there are two Kelvin balance wattmeter elements shown connected to measure the power in two separate circuits. Although only

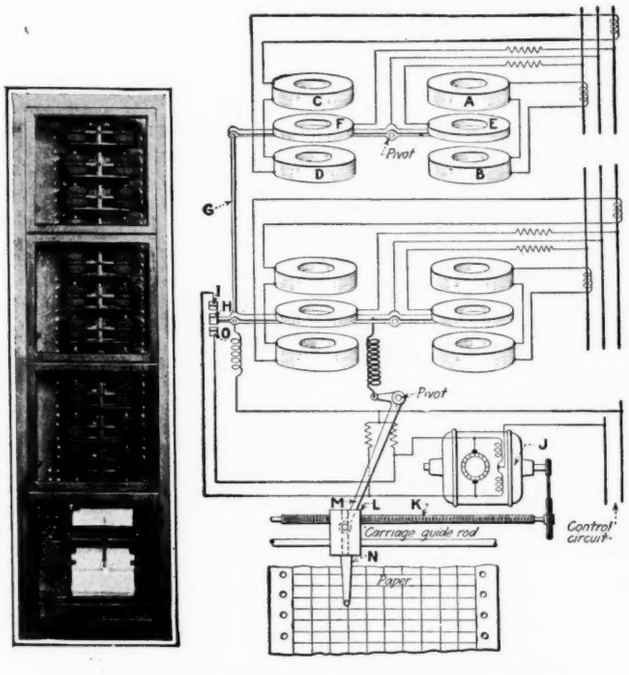


Fig. 5, left—Totalizing recording wattmeter. Fig. 6, right—Schematic diagram of totalizing recording wattmeter

two are shown here, any number up to 12 may be employed. Each Kelvin balance consists of four stationary current coils and two movable voltage coils. The two right-hand coils *A* and *B* carry the current of one phase, while *C* and *D* carry the current of another phase. The moving coils *E* and *F* (pivoted as shown) are connected to the lines through resistors. When power flows in the positive direction, coil *E* moves downward and coil *F* upward; or in other words, the moving element tends to rotate in a clockwise direction around the pivot.

Each element has the same characteristics, and they are all connected mechanically together by a flexible strip *G* on their left-hand side. This clockwise move-

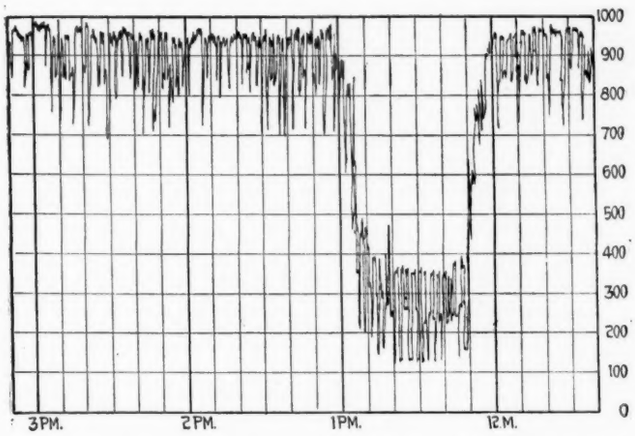


Fig. 7—Section of graphic record of load obtained on totalizing wattmeter

ment has unbalanced the equilibrium of the meter and a contact *H*, mounted on the moving element, touches a stationary contact *I* and causes the armature of motor *J* to rotate in a given direction. This motor is belted to the worm *K* on which rides the pen carriage *L*. This carriage has a vertical slot in its back in which moves a pin attached to the arm *M* which carries a spring at its upper end, the other end of the spring being attached to the moving element. As the worm *K* revolves, it moves the pen carriage to the right. This causes arm *M* to follow it, and as this arm rotates around the pivot, increases the spring tension and tends to pull the coils of the Kelvin balance in a counterclockwise direction. This movement of the pen carriage and increasing spring tension continue until the electrical torque of the elements in a clockwise direction is exactly balanced by the mechanical pull of the spring in a counterclockwise direction, at which point the contacts *H* and *I* open and the motor stops instantly. The position of the pen *N* on the paper chart now indicates the load on the system, as in Fig. 7.

Should the load fall off, contacts *H* and *O* would close and the motor rotate in the opposite direction, moving the pen carriage to the left until the decreased spring tension again balanced the decreased electrical torque, when the contacts open again. Thus for every load the pen will assume a definite position on the paper.

In designing the connections, care must be taken to select correct transformer ratios and correct calibrations to produce correct results. For example, if two circuits of 500 amperes and 1,000 amperes each were totalized, transformers of 500 to 5 and 1,000 to 5 could be used, but the elements of the meter should be calibrated for this condition. For the first load, 5 amperes and 100 volts applied, the meter element would be adjusted to produce a deflection of, say, 100 kw. on the dial or chart; for the second, 5 amperes and 100 volts applied, the meter element would be calibrated to produce a deflection to 200 kw. on the dial or chart. This calibration is usually obtained by varying the series resistor in the potential circuit.

The Cross-Compound Turbine Adaptable to a Variety of Conditions

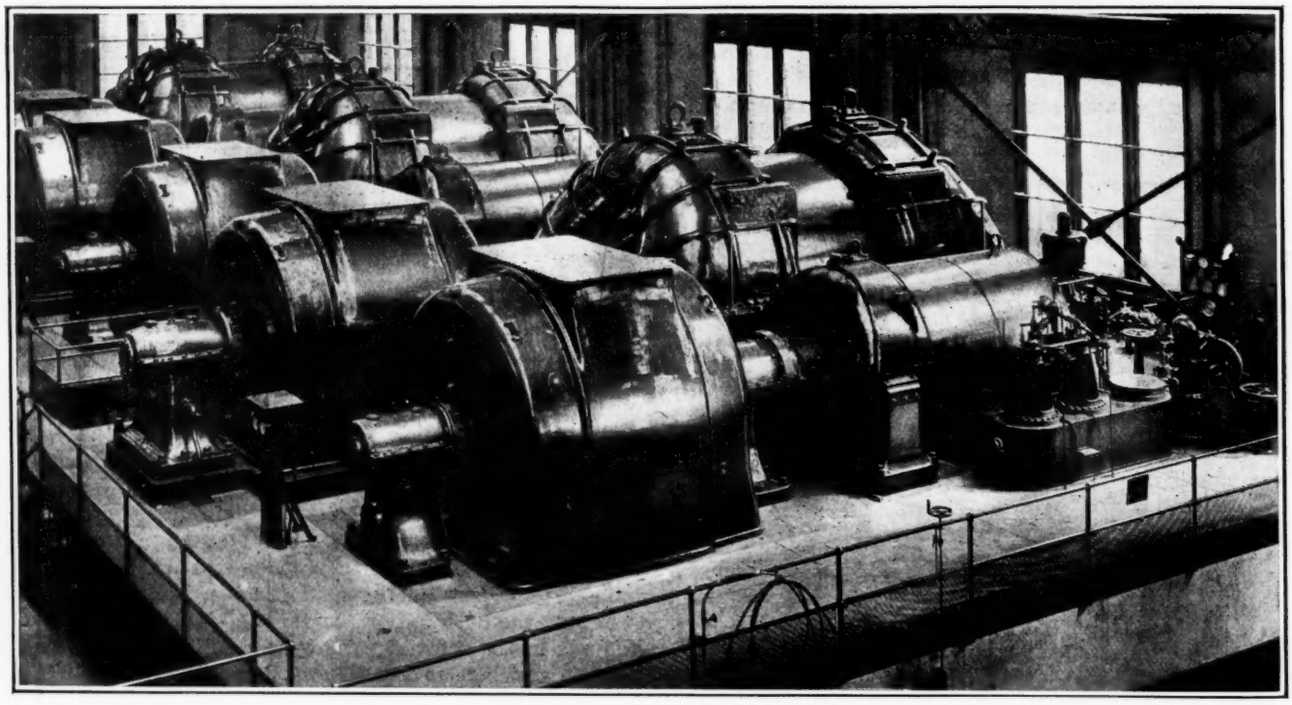
By EUSTIS H. THOMPSON

Applications of the cross-compound principle indicate a growing appreciation of the desirable characteristics of this type. A consideration of such units of today brings to light a number of ways in which this construction may be utilized and suggests an increasingly important field in the future.

A RECENT demand for cross-compound turbines has served to focus attention on this type of prime mover. The expansion cycle is here carried out in two or more turbine elements driving separate generators, and sometimes operating at different synchronous speeds. A study of the present units indicates many characteristics that may be taken advantage of, so that this type may be adaptable for a number of purposes.

The compound principle of construction is not new, but has been employed in connection with every important step in the advance made in the art of turbine building, and has primarily been employed for the purpose of securing a combination of the highest possible reliability and efficiency. From 1900 to 1903 it was standard practice both in this country and Europe to employ tandem compound turbine elements driving single generators in condensing-type units of 1,500 kw. capacity.

The cross-compound principle, however, where separate generator elements were operated at different synchronous speeds, originated with the 30,000-kw. machines installed at the Seventy-fourth Street Station of the Interborough Rapid Transit Co., New York City, in 1914. The advantages of the cross-compound turbine become increasingly important as prime movers become larger in individual capacity, steam pressures are increased, temperatures raised, and the steam reheated after partial expansion has taken place so as to decrease the moisture in the low-pressure stages and thereby materially improve economy. The general demand for higher efficiency and greater reliability, together with operating records of machines of this type in service, is instrumental in bringing about its wider adoption.



High-pressure element at 1,500 r.p.m exhausts into 750-r.p.m. low-pressure elements of 30,000-kw. cross-compound units

In comparison with a single-cylinder unit the cross-compound may be designed with less blading, higher efficiency and greater rigidity generally speaking. However, in many cross-compound units there is a tendency to increase the number of blade rows over that of an equivalent single-cylinder turbine for the purpose of obtaining higher over-all efficiency. In such a case less blading material does not necessarily result.

Apart from these considerations, the greater reliability is possibly the principal single factor that may be said to favor the cross-turbine design.

Where a large single-cylinder unit is considered, some compromise in material, efficiency or reliability is inevitable either at the high- or low-pressure ends in order

to operate both at the same speed. Low-pressure vanes are naturally subject to much greater centrifugal forces than those of the comparatively small high-pressure blading, in a single-cylinder unit. It is therefore frequently more convenient to proportion the low-pressure element of a cross-compound unit for a lower speed than the high-pressure. It is possible to obtain an increased efficiency for high-pressure blading at high speed under some conditions. With the same number of blade rows the material decreases approximately as the square of its speed. With shorter rotors, as is possible in compound turbines, rigidity is more easily attained. In units of large size the low-pressure element may be built at a reduced speed, giving lower unit stresses and therefore higher real operating safety factors, in both turbine and generator.

Reliability is increased from several standpoints. In many cases inspections of the interior may be carried out during the week-end shutdown periods, by inspecting one element at a time. The smaller and lighter individual parts require less time for dismantling and entail less risk in handling. The necessity for a smaller crane may be, under such conditions, made the means for saving an appreciable expense if a lighter supporting structure is utilized.

Electrical Trouble Confined to One Element

In regular operation there is a larger margin for reliability from the fact that any mechanical or electrical trouble may be confined to the element of the turbine in which it originates, leaving the remainder of the unit available for operation. For the utilization of severe steam conditions a high-pressure element may in itself be subjected to these uncertainties, thus localizing trouble that may occur. This idea may be carried out to the extent of isolating the high-pressure units in a location widely separated from the remainder of the plant.

Where the reheating cycle is employed, there are two possibilities presented. Piping for this cycle is liable to be bulky. With a cross-compound unit, the low- and high-temperature lines may be connected at each end of a cylinder in the usual manner, so as to give plenty of room for connection to the turbine and the installation of auxiliary valves and other devices. Not only this, but secondly, means of isolating temperatures to some extent are made possible, so that each element may be subjected to a continuously falling temperature from throttle to exhaust, instead of hot and cooler conditions occurring close together near the middle of the turbine. Expansion is much easier to take care of as each element would then be equipped with only the usual supply and exhaust piping.

Automatic division of load is another factor inherent in the cross-compound principle and may be taken advantage of in several ways. When a reduction gear is required, such as in a marine drive, or for a large direct-current generator, both units may connect to the same gear through individual pinions. The high- and low-pressure elements may then be operated at speeds suitable to their requirements of design.

The reduction gear itself is under more favorable conditions when driven by two pinions, with one on each side, than by one alone. Side thrust is thus eliminated, and only one-half the face width of the gear is required, as compared with that driven by only one pinion. This hinges on the fact that both elements may be designed to give approximately equal torque to the pinion at normal load. Reliability is here an inherent advantage over that of a single-cylinder turbine, since either may be arranged to operate in case of one being out of commission.

Objections that have at times been brought up against large cross-compound units for power-plant work are those of increased cost and complications attending the use of two or more generators. With two generators duplicate switches for the main armature circuits, and duplicate field-control equipment, blowers, etc., and a necessity of phasing in two or more generators when starting up, appear to be undesirable.

As a matter of fact the main switches for two or more generators may be so interlocked mechanically and electrically as to be handled as one single switch. If desired, the leads may be solidly bolted together between generators, and one common line for both taken to a single switch for the armature current. Fields may be operated either in multiple or in series through a single rheostat. The generators may be automatically phased in with each other before being thrown on the busbars simply by bringing them to somewhere near an equal speed, connecting their armature circuits together, and gradually circulating a small field current through both. This is not inherently necessary, for considerations of the generator. If a field is applied to both machines and then one is started, the second will be revolved as a synchronous motor. Steam may then be applied, and both turbines brought to speed in synchronism.

Load and power factor are automatically divided so that individual adjustment is not generally necessary. Cross-current or load surging under any condition, is a matter of adequate governing and generator design, rather than that of objectionable qualities inherent in generators of cross-compound turbines.

Condensing Equipment Determines Floor Space

This type is inherently more expensive than the single-cylinder or tandem compound, except in very large capacity. The floor space required is not necessarily greater, as the latter is often determined by space for the condensing equipment rather than that of the turbine. Against this, however, is balanced the item of reliability, which the cross-compound unit possesses in many ways, to a greater degree than other types.

In relation to future prime movers we may look forward to higher pressures and temperatures. The high-pressure element of a cross-compound machine may be specialized in some ways to a greater extent than a single-cylinder machine. It should not be lost sight of that a closer union between prime mover and boiler may be more advantageous at extremes of elevated temperatures and pressures. Where expansion of piping is a serious factor, a comparatively small high-pressure element may be constructed so as to move with this expansion. With elevated temperatures strength may be obtained, generally speaking, by adding material. Flexibility, however, drops off more rapidly in ordinary materials as temperatures are raised, and yet it becomes a greater desirability in connection with the increased expansive forces which must be dealt with. The piping at extremes of temperature will thus be relieved largely of the requirement of flexibility. In a binary vapor cycle, where steam and other vapors may utilize a common source of heat, the cross-compound principle is subject to further adaptation.

Determining the Type of Vacuum Pump for Given Air Removal Conditions

By C. M. REED*

A ROTATIVE dry vacuum pump is nothing more nor less than a piston-type air compressor, and the quantity of air actually handled will be less than the piston displacement by an amount depending upon the mechanical construction of the pump, the absolute pressure at the pump suction, the amount of water vapor present in the air handled, etc. Most guarantees for rotative dry vacuum pumps are based upon tests made when handling expanded atmospheric air. Some manufacturers are careful to state that the pump will not have its guaranteed efficiency when handling a mixture of air and water vapor. Such guarantees are usually expressed in terms of cubic feet of "free" (or atmospheric) air handled per minute at the specified rotational speed.

On the other hand, a steam-jet vacuum pump has no mechanically operated parts, the air being removed by frictional entrainment with jets of steam moving at a high velocity. Compression is brought about by the gradual reduction of velocity in a suitably designed throat or diffuser section, potential energy being gained at the expense of the kinetic energy of the jets.

It has been demonstrated[1] by actual tests that the *volume* of air-steam mixture handled by a steam-jet pump increases rapidly with decreasing absolute suction pressure, which is diametrically opposite to the characteristic of a rotative dry vacuum pump. It is noteworthy that manufacturers of steam-jet vacuum pumps base their guarantees on the number of pounds of dry air removed per hour under pump suction conditions, instead of on a volumetric basis of expanded atmospheric air.

It has been shown in a previous article that while the weight of dry air to be removed per hour from a barometric condenser is independent of the type of condenser, the volume of air-steam mixture is greater in the case of a parallel-current condenser than in the case of a counter-current condenser.

Taking these facts into consideration and also the characteristics of both types of pumps, it will be seen that practically the same size of steam-jet vacuum pump may be used with either type of condenser and that a much larger rotative dry vacuum pump will be required for a parallel-current than for a counter-current condenser.

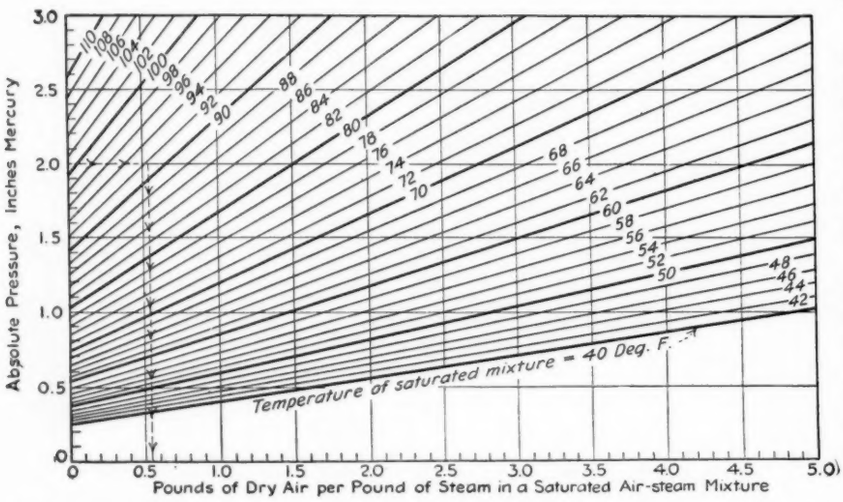

Absolute Pressure, Inches Mercury
Pounds of Dry Air per Pound of Steam in a Saturated Air-steam Mixture
Temperature of saturated mixture = 40 Deg. F.

Fig. 1—Effect of air leakage upon condenser pressure when condensing non-superheated steam at medium temperatures

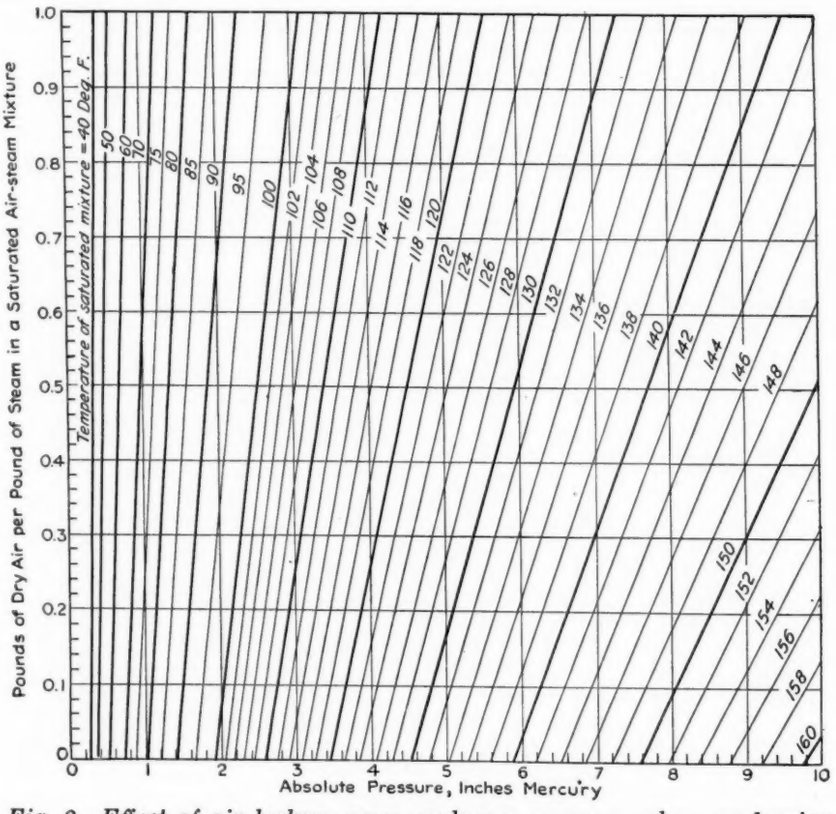

Pounds of Dry Air per Pound of Steam in a Saturated Air-steam Mixture
Temperature of saturated mixture = 40 Deg. F.
Absolute Pressure, Inches Mercury

Fig. 2—Effect of air leakage upon condenser pressure when condensing non-superheated steam at temperatures higher than in Fig. 1

*Mechanical Engineer, Portsmouth, Va. An article by the author in the March 4 issue described how to calculate the air liberated in a barometric condenser. Vacuum pump selection is herein taken up.

[1]Stuart & Senner, Jour. Am. Soc. Naval Engineers, August, 1920.

In case it is necessary to install a new dry vacuum pump for an existing condenser installation, a simple test may be made to determine the actual amount of air to be removed. The absolute pressure and the temperature are measured in the condenser head at a point where any possible superheat in the steam has been removed, care being taken to insure that no condensing

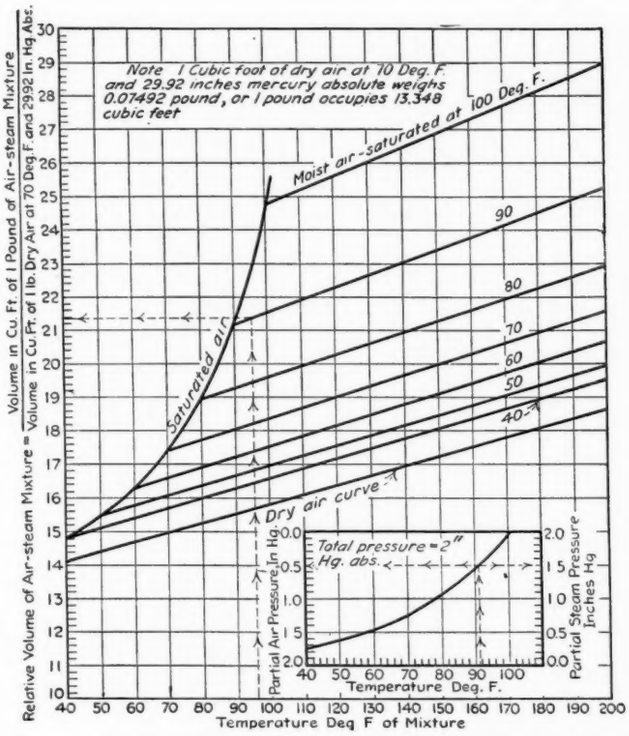

Relative Volume of Air-steam Mixture = Volume in Cu. Ft. of 1 Pound of Air-steam Mixture / Volume in Cu. Ft. of 1 lb. Dry Air at 70 Deg. F. and 29.92 In. Hg Abs.
Note 1 Cubic foot of dry air at 70 Deg. F. and 29.92 inches mercury absolute weighs 0.07492 pound, or 1 pound occupies 13.348 cubic feet
Moist air-saturated at 100 Deg. F.
90
80
70
60
50
40
Saturated air
Dry air curve
Total pressure = 2" Hg. abs.
Partial Air Pressure, In Hg.
Partial Steam Pressure Inches Hg
Temperature Deg. F.
Temperature Deg F of Mixture

Fig. 3—Relative volumes of dry air in air-steam mixtures. Dalton's law is illustrated below

The mixtures are assumed to be at 2 in. mercury absolute pressure. Dry air before mixing is assumed to be at 70 deg. F. and 29.92 in. mercury pressure absolute. The small curve below illustrates how both partial air and steam pressures may be obtained according to Dalton's law.

water strikes the thermometer. A simple application of Dalton's law will give the number of pounds of dry air present per pound of steam.

Dalton's law states that the total pressure exerted against a container filled with a mixture of gases and vapors is the sum of the pressures that would be exerted by each of the gases or vapors considered independently of the others. For example, consider 1,000 cu.ft. of a saturated air-steam mixture at a temperature of 91.8 deg. F. and a total pressure of 2.00 in. mercury absolute. The steam pressure corresponding to 91.8 deg. is 1.50 in. mercury absolute, hence the "partial" air pressure must be, by difference 2.00 — 1.50 = 0.50 in. mercury absolute. This may be worked graphically by means of the curves of partial steam and air pressures, Fig. 3.

Transposing formula (1) given by the author in the previous article ("Calculating the Amount of Air Liberated in Barometric Condensers," in the March 4 issue), we obtain the expression

$$M = \frac{pV}{R(t + 458.5)}$$

in which M = pounds of gas present; p = absolute pressure in pounds per sq.ft. (partial pressure in this case); V = volume of gas in cu.ft.; R = "Gas Constant" (53.35 for air and 85.89 for water vapor); and t = Fahrenheit temperature of gas.

For the example given, considering the air first, we have

M_1 = [0.50 × 0.491 × 144 × 1,000] ÷ [53.35(91.8 + 458.5)]
= 1.207 pounds of air present,

M_2 = [1.50 × 0.491 × 144 × 1,000] ÷ [85.89(91.8 + 458.5)]
= 2.246 pounds of steam present.

Then the pounds of air per pound of steam will be 1.207 ÷ 2.246 = 0.538.

The same result may be obtained from the curves of Fig. 1 by entering at the left with a total pressure of 2.00 in. mercury and projecting up to a point between the 90-deg. and the 92-deg. curves, representing 91.8 deg. F., and reading 0.538 lb. air per pound of steam on the scale at the bottom.

Multiplying the ratio of air to steam present by the number of pounds of steam condensed per hour will give the total pounds of dry air which must be removed per hour.

When making the test described, reasonable care must be taken in locating the thermometer so that it will not be in an air pocket and that it will be in contact with the air-steam mixture before condensation is complete, although Bancel has shown that there will be no

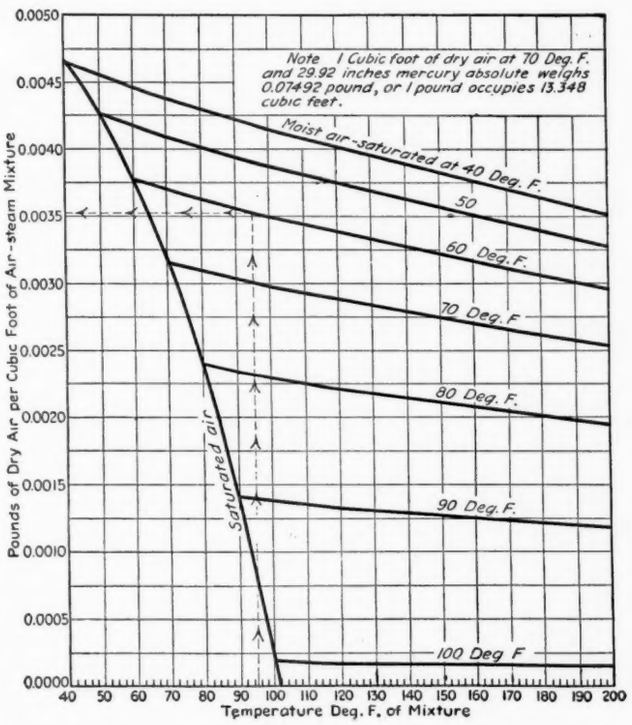

Note 1 Cubic foot of dry air at 70 Deg. F. and 29.92 inches mercury absolute weighs 0.07492 pound, or 1 pound occupies 13.348 cubic feet.
Moist air-saturated at 40 Deg. F.
50
60 Deg. F.
70 Deg. F
80 Deg. F.
90 Deg. F.
100 Deg. F
Saturated air
Pounds of Dry Air per Cubic Foot of Air-steam Mixture
Temperature Deg. F. of Mixture

Fig. 4—Relative weights of dry air in air-steam mixtures. Other conditions as mentioned in Fig. 3

reduction in temperature until condensation has been approximately 99 per cent completed. If the steam to the condenser is superheated, the superheat must be destroyed by a small jet of water or other means before the temperature is measured.

The curves of Figs. 1 and 2 have been prepared to eliminate calculation in determining the ratio of dry air to water vapor in saturated mixtures. Fig. 2 is for mixtures at higher temperatures than in Fig. 1.

It is not usually practicable to make a capacity test of a vacuum pump with air under the conditions that will obtain in a condenser installation. It is necessary, consequently, to know what volume of atmospheric air will be equivalent to the amount of mixture that the pump must handle.

For the purpose of simplifying calculations of this kind, the "Relative Volume" curves in Fig. 3 have been prepared. For example, consider a pump capacity of 235.8 cu.ft. per minute of mixture at 2.00 in. absolute, a temperature of 95 deg. F. and saturated at 90 deg. Entering Fig. 3 at the bottom with a temperature of 95 and projecting up the "Relative Volume" curve for a saturation temperature of 90, the "Relative Volume" is found to be 21.34; hence the volume of dry air at 70 deg. and 29.92 in. mercury absolute, which must be pumped during a test, will be $235.8 \div 21.34 = 11.04$ cu.ft. per minute.

Again, it may be desired to replace an existing rotative dry vacuum pump with a steam-jet pump. In this case the weight curves in Fig. 4 will be very convenient. For example, consider a counter-current condenser having an inlet-water temperature of 60 deg. F., a vacuum pump suction temperature of 95 deg. and a known actual pump capacity of 250 cu.ft. per min. at 2.00 in. mercury absolute pressure. Entering Fig. 4 at the bottom with a temperature of 95 and projecting up to the weight curve for a saturation temperature of 60 deg., it will be found that each cubic foot of air-steam mixture at a temperature of 95, a pressure of 2.00 in. mercury absolute, and saturated at 60 deg. contains 0.003525 lb. of dry air. Dotted lines show a point for 60-deg. vapor. The required steam-jet pump must therefore handle $250 \times 60 \times 0.003525 = 52.87$ lb. dry air per hour.

On the other hand, if a pump having an actual capacity of 540 cu.ft. per min. is being used in connection with a parallel-current condenser having an outlet water temperature of 90 deg. F., it will be found that each cubic foot of mixture at 95 deg., a pressure of 2.00 inches mercury absolute, and saturated at 90 deg. contains 0.00139 lb. dry air, and a steam-jet pump to handle $540 \times 60 \times 0.00139 = 45.1$ lb. dry air per hour will be required.

It has been shown that when using a steam-jet vacuum pump it is immaterial whether a counter-current or a parallel-current condenser is installed, but that when using a rotative dry vacuum pump a much larger unit will be required for use with a parallel-current than with a counter-current condenser.

A method for determining air-removal requirements for an existing plant by means of a simple test has been presented by the author in a previous issue as noted. Figs. 1 and 2 have been prepared for the purpose of simplifying calculations in connection with such a test.

The Diesel Engine in Medium-Powered Central Stations*

By Ray C. Burrus

As a preliminary to the investigation of the Diesel engine as a prime mover for the medium-capacity central station a review of the indictment that may be brought against the average steam plant is of interest. A pile of coal weighing 180 lb. contains heat units equivalent to 1,000 horsepower-hours. Even the large central station, in utilizing the heat of this weight, uses an additional 1,020 lb. from which no return is derived. This is a very poor showing considering the elaborate layout and costly equipment of the large station. However, the smaller steam plant presents a picture of far greater waste. Throwing away heat through the stack, in the ashpit, through the steam pipes and in the engine, as it does, 1,882 lb. of coal is wasted for every 118 lb. actually utilized. The ratio of waste to utilization is very nearly 15 to 1. On a dollars and cents basis, the profligacy of this waste is

Fig. 1—What happens to a ton of coal; 118 lb. utilized, 1,882 lb. lost

best emphasized; for every $10 that the steam plant invests in coal, but 64 cents worth is turned into electrical or mechanical energy.

It is admitted that even the small steam plant can show improvement in economy provided certain elaborate and expensive changes are made. There are on the market many types of auxiliary equipment and apparatus, the adoption of which would no doubt reduce the cost of power per unit generated, but this material necessarily adds to the maintenance expense of the plant as well as the investment and overhead. There is a limit of efficiency however, that cannot be exceeded no matter how much improvement or redesign is incorporated.

The waste of 1,882 lb. of coal for every 118 lb. actually utilized gives the average steam plant an overall efficiency of less than 6½ per cent. This measure is made from the coal pile to the busbar, for to refer to engine efficiency alone is not a fair or even accurate measure of the performance of the complete steam plant. Conversely, when the efficiency of the Diesel engine is noted as being 30 to 33 per cent, it is on the same scale as the coal-pile to busbar measure, for the Diesel is a power unit complete within itself. The long line of energy transformation of the steam plant with its inherent losses that cannot be overcome or lessened, are not to be found in the Diesel installation.

While the waste of coal is the largest, there are other losses of no less importance in their effect on the production cost of the station. Man power is wasted and this increases power costs as markedly as does coal waste. An engineer and fireman for each shift represents the minimum personnel permitted in any station. The number of men employed increases where plants of more than 200 hp. are considered. The Diesel engine, on the other hand, is a one-man unit; in fact, one competent operator can successfully care for the operation of two units, depending, of course, on their size and the condition of the load.

Maintenance, too, must be considered in determining the losses. The steam-plant installation includes, in

*Extract of Paper read before the St. Louis Section, American Society of Mechanical Engineers, April 22.

addition to the primary equipment, much auxiliary apparatus that requires regular and frequent overhauling. The maintenance record of any steam plant gives a large list of material subject to wear and disintegration.

A typical municipal installation may be found at Altus, Okla., a town of 6,000. The old steam-driven power plant at Altus was built in 1911, and while it was giving satisfactory service, it was expensive to operate, mainly because of coal consumption and labor charges. In 1922 the city installed three vertical Diesel engines, two of 380 and one of 285 horsepower. As soon as the engines were completely installed, the steam plant was scrapped. Recently, Altus has placed an order for a 750-hp. Diesel which will be able to carry the normal loads; one or more of the smaller engines will be used during the peak-load period.

The situation at Altus emphasized one of the advantages of a Diesel installation. The municipal or industrial plant need not be burdened with the expense of installing equipment for a capacity very much beyond the immediate demands or the demands that can be anticipated for a period of two or three years. Multiple units are feasible, since the economy of production is not dependent on the size of units. In the case of a steam-plant installation, the designing engineer usually provides auxiliary equipment, pumps, feed-water heaters, coal bunkers and room space so much in excess of

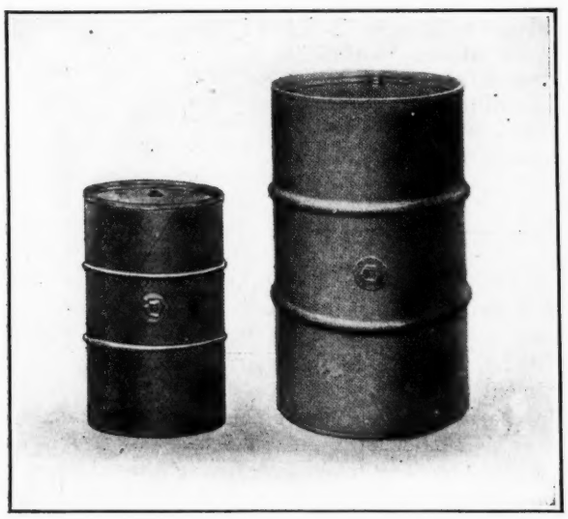


Fig. 2—A barrel of oil; 30 per cent transformed into electrical energy

present and immediate demands that the operation is burdened with unreasonable overhead charges. With Diesel installation of adequate size to meet immediate and closely determined future needs, there is opportunity to realize on the investment before additional equipment is purchased.

For the two years the first Diesel installation has operated, the Altus plant has realized considerably better than 25 per cent on the investment. As a matter of fact, the savings for two years made possible by the Diesel plant just about meet the expense of completely installing the new 750-hp. unit. Turning to the annual report for the year 1923, which in the accompanying table has been compared with the totals for the last year of the steam plant's operation, it is seen that the total cost, operating and overhead, is less than the coal bill of the steam plant.

The Diesel is, in many instances, better than competitive with high-line electric power. Another community of about 8,000 people, Pawhuska, Okla., is in close proximity to and could easily purchase power

ALTUS, OKLA., MUNICIPAL LIGHT PLANT

	Steam Plant	Diesel Plant
Plant equipment	3—2,000-sq.ft. boilers 1—200-kw. Corliss engine 1—150-kw. Corliss engine	2—250-kw. Diesels 1—192-kw. Diesel
Plant capacity, kw	350	692
Plant cost	$35,000.00	$126,000.00
Cost per kilowatt capacity	100.00	182.00
Plant life, years	11	20*
Annual Cost of Operation		
Depreciation	$2,000.00	$6,300.00
Average interest on investment	1,145.45	3,969.00
Insurance	300.00	525.75
Fuel	28,476.45	5,335.56
Lubricating oil and waste	1,150.38	363.00
Water	1,277.50	52.20
Attendance	11,476.46	7,920.00
Repairs	1,500.00	79.57
Misc. expense	.....	175.00
Total	$47,326.24	$24,720.08
Output, kw.-hr.	1,168,125	1,481,070
Cost per kw.-hr., cents	4.05	1.67
Percentage reduction in cost		59
Savings per year		$35,294.47
Net return on new investment, per cent		28

* Estimated

from, a high-tension transmission line. From 1907 to 1920 power was generated in a steam plant where in the last three years of its service the cost per kilowatt-hour was 4 cents. Two Diesel units of 192-kw. capacity each were installed, and as Table II will show, the cost has been reduced to a little over one cent per kilowatt-hour.

For a consumption of 2,000,000 kilowatt-hours per year the transmission line offers a rate of a little over 2½ cents per kilowatt-hour. The annual report for 1923 shows the savings the Diesel makes possible over

OPERATION COSTS IN PAWHUSKA, OKLA., MUNICIPAL LIGHT PLANT

Depreciation, 5 per cent	$4,000.00
Average interest on investment	2,520.00
Insurance	750.00
Fuel	8,218.56
Lubricating oil	1,538.42
Attendance	6,300.00
Repairs	475.20
Miscellaneous expense	120.00
Total cost operation one year	$23,922.18
Output, kw.-hr.	2,138,832
Savings due to Diesel Plant	
Cost per kw.-hr., steam plant	$0.0400
Cost per kw.-hr., transmission line current	.0263
Cost per kw.-hr., Diesel plant	.0112
Saving per kw.-hr. over steam-plant cost	.0288
Saving per kw.-hr. over purchased power	.0151
Total saving per year over steam-plant cost	$61,598.36
Total saving per year over purchased power	$32,296.36

steam-plant operation, as well as over the cost of purchased current. So conclusive are the results that this community has purchased a third unit.

In a recent lecture before the Institute of Metals, London, Dr. F. W. Ashton gave several methods of picturing the size of an atom. One is to imagine a cube of lead one decimeter (about 4 in.) on the side. Cut this in half along each of its three dimensions—that is, cut it up into eight cubes. Take one of these eight and divide it into eight more. Repeat this process twenty-eight times, and the final cube will be about the size of an atom of lead. Now, if all the atoms in the original cube were placed in a single line, spaced as in the actual block of lead, the line would extend six trillion miles. Again, if an ordinary electric-light bulb were pierced with an aperture of such a size that one million molecules of air could enter per second the pressure in the bulb would not rise to that of the air outside for one hundred million years.

The Sphere of Boiler Compound—Colloid Chemistry and Scale Prevention

By E. M. PARTRIDGE*

WHILE boiler compound is widely used and is admittedly an efficient method of treatment, the attitude is often met with that its employment should be limited to the treatment of water of but low degrees of hardness. The purpose of this article is to point out as eroneous the reasoning on which this attitude is based and to show why the hardest waters may sometimes be treated by boiler compound with better results than if an external method of treatment be adopted.

To bring out the reasoning by which this conclusion is reached, it is necessary to mention briefly what occurs when lime and soda or zeolite treatment is adopted, since it is the blind following of the principles concerned therein that has led to the conclusion that compound treatment is not adapted to use on hard waters. The principal mineral salts dissolved in the ordinary boiler-feed water are those of calcium, magnesium and sodium, and they are most frequently in the form of bicarbonates, sulphates or chlorides. The calcium and magnesium salts constitute the hardness and the scale-forming substances in the water. The sodium salts when in low concentration are of little importance, but in higher concentrations cause foaming[1] and may be responsible for the occurrence of corrosion.

IN THE following, it is not the intention to convey the impression that compound is at all times the best treatment for boiler-feed water, but rather to point out that the chemistry of compound or interior treatment is essentially different from the chemistry of water softening. An important phase of compound treatment involves the addition of colloidal matter to the water, which may or may not enter into chemical combination with the scale-forming salts, but which does affect their physical nature when precipitated, so as to render them sludge-forming rather than scale-forming.

When zeolite treatment is employed, the hardness and consequent scale-forming properties of the water are removed by the replacement of the calcium and magnesium in the water by sodium. This means an increase of the sodium-salt content of the water. For instance, if calcium sulphate occurs in the water before softening, it is replaced in the softened water by sodium sulphate. No diminution of the total solid content of the water takes place.

Lime-and-soda treatment may effect a reduction in the total solid content of a hard water by removing a considerable portion of the carbonate hardness completely from the water through the action of the lime used, but the use of soda, as in the case of zeolite softening, simply replaces the scale-forming salts with which it reacts by the corresponding sodium salt with the resultant increase of the sodium-salt content of the water.

These external treatments or softening methods involve chemical reactions of a simple and well-understood type, that of double decomposition, in which the interchange of two elements present in two different compounds results in the formation of two new compounds. Thus, sodium zeolite and calcium bicarbonate react to give calcium zeolite and sodium bicarbonate, or in the lime-soda softener calcium sulphate and sodium carbonate react to give calcium carbonate and sodium sulphate. The reactions take place in perfectly definite chemical proportions, and since their exactness is brought to the attention of the external-treatment chemist time and again, he is wont to assume that this type of reaction is the only one applicable to the treatment of water, whether without or within the boiler. This is what was meant when reference was made to the blind following of the principles involved in external treatment.

Boiler-compound formulas on the other hand have generally been developed by individuals of little chemical knowledge, who found by actual trial that certain substances added to their boiler-feed water improved results in the boiler. Their assertions that their compound did the work, but nobody knew how it acted, were treated with such scorn that many of them thought up weird explanations of how their material pried the scale off the boiler tubes, reached out with hooklike tentacles to pull down the scale-forming matter, etc., with the result that they were rightfully laughed at by chemists in general, particularly external-treatment chemists.

Furthermore, since boiler compounds commonly contain soda ash, caustic, etc., a rather unwarranted assumption has been made concerning the uniform purpose of all the materials in any compound. It is known that such sodium compounds added to boiler-feed water in sufficient amount will convert all the sulphate hardness to carbonate hardness, which is the less objectionable form of the two, and an excess will prevent the carbonate scale that is precipitated under these conditions from forming a hard adherent scale. The reaction with the sulphate hardness in the water is the same whether it takes place in the boiler or in the reaction chamber of a lime-soda softener, with one difference, which the lime-soda expert has been quick to point out—when used in the lime-soda softener, the sodium-salt content of the water is increased accordingly, but the insoluble calcium carbonate that forms is precipitated and removed from the water in the settling tank before the water passes to the boiler. When the reaction takes place in the boiler, not only is the sodium salt content of the water increased, but the precipitated calcium carbonate is in suspension in the boiler water. What does not settle as a sludge may form a carbonate

*Chief chemist, Paige & Jones Chemical Co., Hammond, Ind.

[1] S. W. Parr, "Fuel, Gas, Water and Lubrication," 117 (1922).

scale, with the result that the scale is not removed but merely made less objectionable, and an increase in sodium salts occurs which may cause foaming or corrosion just as in the lime-soda softened water.

Obviously, if a very hard water were to be thus treated with soda ash or caustic, the boiler water would be so loaded with sodium salts and suspended matter in the form of calcium carbonate, that its use would be impossible. This is the idea back of the statement that compound should be used only on moderately hard waters since it is assumed that treatment of the water can be successfully accomplished only by chemicals that react quantitatively with the salts present.

Boiler Compound Chemistry Involves Other Principles

Successful boiler-compound treatment of a hard scale-forming water is not based on chemical reactions of the nature just discussed. Boiler-compound chemistry and water-softening chemistry differ. It is possible to affect the scale-forming character of a water by other means than adding chemicals which act directly with the scale-forming salts present.

When, through concentration of the boiler water or lessened solubility at the boiler temperature and pressure, the scale-forming salts come out of solution, they do not appear immediately as hard crystalline scale on the boiler parts. On first becoming insoluble, the scale-forming matter is suspended as minute particles throughout the boiler water. It has become an insoluble precipitate without the addition of chemicals, and whether or not it will form scale depends upon whether or not it will attach itself and crystallize into hard scale on the boiler parts. We can prevent its doing this by various means, but this article is not meant to be a complete discussion of the principles of boiler-compound treatment. The intention is rather to outline the theory of one explanation of results that can be attained. In doing so it will be necessary to ignore for lack of space other explanations of the phenomena discussed, leaving the footnotes to guide those who wish confirmation of the facts developed.

We may start with a consideration of surface tension. The surface of a liquid behaves as if an elastic membrane were stretched over it. We may float a needle on the surface of a glass of water if we do not break the "skin" of the water. If a drop of water is placed on a flat plate, there are two opposing forces tending to give it shape. Gravity acts to flatten it out, but the pull of surface tension acting over the surface of the drop draws it into a rounded shape, just as the tension on the rubber of an inflated toy balloon rounds it out.

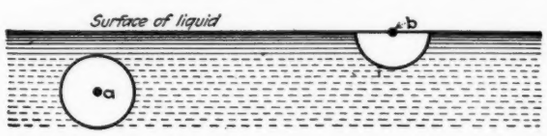


Fig. 1—Why tension exists in the surface film

Particle *a* is attracted equally in all directions, while particle *b* is attracted only from the sides and below, so that the surface acts somewhat like a stretched sheet of rubber.

Laplace[2] developed the theory that this tension arises from the attraction of the molecules of the liquid for each other. Those in the interior of the liquid are attracted equally from all sides, but those at the surface are subjected to an unbalanced attraction. Thus, in Fig. 1, particle *a* is attracted from all directions by other molecules over the radius of molecular action, while particle *b* at the surface is attracted from below almost entirely. This "pull" on all particles in the surface causes a different condition to exist there from that in the interior of the liquid and is responsible for the surface tension.

We are prone to forget, when we speak of the surface tension of water, of ether, of olive oil, etc., that we commonly refer to the surface tension of the substance in question in contact with air. But its surface tension in contact with something else may be different. Thus, water has a certain surface tension in contact with air. If we cover the water with a layer of gasoline, the surface of the water is in contact with the gasoline and exhibits a different tension from that when it was in contact with air.

Fig. 2—Three surface tensions shape castor-oil drop

Acting like three rubber bands of different tensions, the balance between the three different tensions in surfaces 1, 2 and 3 determines the shape of the drop.

When a drop of one liquid is placed on the surface of another liquid, we have three surface tensions to consider, each of the two liquids to the air and the two liquids to each other. Thus, if we place a drop of castor oil on water, we have, referring to the numbers in Fig. 2, the following surface tensions: (1) Between air and water; (2) between air and castor oil; (3) between castor oil and water.

Surface Tension Compared to Rubber Bands

If we should take a vertical cross-section down through the drop of astor oil and water and consider only the surfaces cut, we might liken them to rubber bands of varying strength. We would have a ring formed by two rubbers (2 and 3) of unequal strength, forming a loop around some oil and two bands of equal strength attached at the sides of this circle. At this point it should be explained that the tension on the surface of a liquid cannot be exactly compared to the tension exerted by a rubber band. As the rubber band shrinks or is pulled out longer, its tension decreases or increases, whereas whether the surface of a liquid be extended or reduced its tension remains the same, as will be apparent from reflection as to its cause.

But we may use our rubber bands to picture the matter to ourselves, and when the drop of castor oil is placed on the water, we can see the possibilities illustrated in Fig. 3.

Since, unlike the rubber band, the surface tension of a liquid does not diminish as the surface decreases, the surface of greatest tension in each of the three cases shown in Fig. 3 is reduced until it disappears. A fourth possibility is that no one tension exceeds the other two and the drop of oil rides in the surface partly in and partly out of the water. In all this discussion the part gravity plays has been negelected.

Now that we have pictured to ourselves some effects of the tension on the surface of a liquid, we can examine its effect in another direction. When we considered a small drop of water on the surface of a plate

[2]Laplace, *Journal of Chemical Science*, 1, 174 (1848).

held in a somewhat spherical shape, we realized that it was holding this shape by its surface tension acting against the flattening effect of gravity. It is seen that the higher the surface tension the larger the spherical drop may be.

When the drop of castor oil was placed on a film of water, it was in contact with water and air. If some castor oil and water be shaken together, the castor oil will leave the surface and form a number of small globules scattered throughout the water. On standing, they separate out again, coalesce and form a large drop on the surface of the water or, if enough be present, a layer there. It will be noted that when the globules of

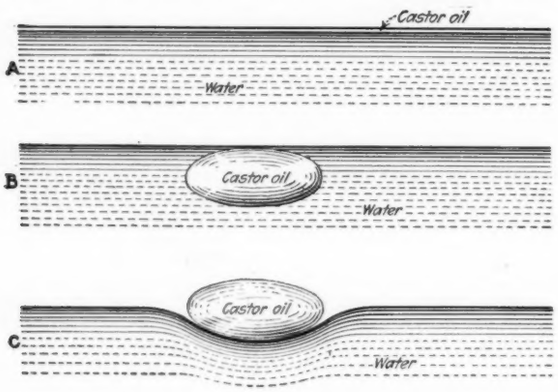


Fig. 3—Effect of various assumed surface tensions

Referring to the three surface tensions shown in Fig. 2; (*A*) if 1 is stronger than the sum of 2 and 3, the oil is stretched out as a thin film on the surface; (*B*) if 2 is stronger than the sum of 1 and 3, the drop will be pushed below the surface of the water; (*C*) if 3 is greater than the sum of 1 and 2, the drop will ride on the surface.

oil are entirely surrounded by water their entire surface is exposed to the water.

When two immiscible[3] liquids are in contact, we call the surface between them the interface. In this instance we have a liquid-liquid interface, although we may similarly have a liquid-solid interface, as for instance, when a powder is suspended in water. The quick coalescence of the castor-oil globules in water is related to the high surface tension at the interface between castor oil and water. As the surface tension at the interface is lessened, the tendency to remain as small separate globules increases until, if no interfacial surface tension exists, the interface has disappeared and the two liquids are miscible in each other.

How Surface Tension Affects Drop Formation

When a liquid of high surface tension with reference to water is dispersed as globules in water, a large amount of surface energy is present. Coalescence allows the exposure of less surface and a more stable condition exists through the reduction of the surface energy in the system. We noted, in our examples of what happened when a drop of liquid was placed on water, that the highest surface tension was eliminated, the surface energy present was reduced and a stable arrangement reached.

Although not so easily demonstrated, it is reasonable to consider solid bodies as possessing surface tension. The surface tension of a liquid increases as it is cooled, and when it solidifies the continuity of phenomena which is the basis of physical science, would lead us to believe that surface tension would not disappear, but would rather have a very high value. If we form a precipitate in a liquid and let it stand, we find that small crystals in a liquid grow at the expense of smaller ones. The growth of small crystals to produce a large crystal may be regarded as analogous to the coalescence of the small drops of a temporary emulsion of castor oil. In one case we deal in the decrease in the energy of a liquid to liquid surface, and in the other case of a liquid to solid surface, but the phenomena are similar.[4]

Just as the position that a drop of liquid will assume with reference to a liquid surface can be explained by the surface-tension effects present, so can the position taken by a number of small solid particles shaken with a mixture of two immiscible liquids be explained. The particles will suspend themselves in one liquid or the other or concentrate at the interface between the two liquids in such a way that the resulting arrangement will leave the least surface energy present in the system. A clear discussion of this is given by Clayton.[5]

Effect of Dissolved Substances

Now if a substance be dissolved in water, it may increase or lower the surface tension of the water. Let us consider the case when it lowers the surface tension. If the surface tension is lowered more and more as the amount of the dissolved substance is increased, it will be seen that, with a given amount of such a substance dissolved, the surface tension would be lessened if the dissolved substance should concentrate at the surface. Such a concentration occurs with the corresponding lessening of surface energy and surface tension.[6] When this happens, more of the dissolved substance is present in the liquid immediately at the surface than in the body of the liquid.

If, now, we consider castor oil shaken to form small globules in suspension in water and add a substance that will lower the surface tension between castor oil and water, we shall find the added substance concentrating at the interface. But the surface tension is thereby greatly lowered and the tendency of the globules to coalesce is minimized. Thus soap lowers the surface tension at the interface, and if castor oil be shaken in water with a small amount of soap present, a permanent emulsion may be formed—the dispersed globules will not agglomerate.

In a similar manner if a finely divided solid be in suspension in water and a substance added that lowers the surface tension, the substance will concentrate at the interface with the result that the small particles of solid matter will lose their tendency to unite and form larger masses. If small crystals be involved, the presence of the proper solvent thus decreases the tendency toward the growth of large crystals. If the dissolved substance be colloidal[7] in nature, it so happens that the concentration at the interface is very great, and the now generally accepted view is that the colloidal matter forms a gelatinous or semi-solid skin around the particles creating the interface.

We have thus what is known as a protective colloid action developed without the necessity of any chemical reaction occurring between the protected solid matter and the colloidal substance added. It will be seen that

[3]Liquids that cannot mix, such as oil and water.

[4]For further information along this line see Willows & Hatschek, "Surface Tension," 27 (1923).

[5]Clayton, Emulsions and Emulsification, 68 (1923).

[6]J. Willard Gibbs, Scientific Papers, 1, 219.

[7]Having the nature of a colloid; that is, a sticky gluey gelatinous substance.

in a boiler we have the scale-forming matter precipitated as fine particles, which can be influenced by the addition of colloidal matter to the water. If a boiler compound then contain colloidal matter, it may prevent the scale-forming matter from forming scale.

Bancroft, in "Rogers' Manual of Industrial Chemistry, Third Edition," says, in speaking of colloidal substances added to boiler compounds, "These colloids undoubtedly prevent the formation of hard crystalline scale, either by preventing to some extent the precipitation of the scale-forming salts or by keeping the precipitate in an extremely fine non-crystalline condition."

Obviously, the addition of such colloidal matter to the water does not increase its sodium-salt content. Compound may, in addition to the colloidal matter present, contain soda ash, caustic, etc., but the effect of the colloidal matter, if properly chosen, allows the use of such a small amount of compound with relation to, say, the amounts of lime and soda that would be used to treat the water, that no important increase in sodium salts occurs. To make this point clear, reference is made to the analyses in the accompanying table. First is given the analysis of a hard water; next is given its composition after treatment with a zeolite softener. The third analysis represents its composition after treatment by lime soda. The fourth analysis gives its composition after treatment by an amount of compound that is giving satisfactory results as to scale prevention.

ANALYSIS OF UNTREATED AND TREATED WATER

(Grains per U. S. Gallon)

	(1) Raw Water	(2) Treated by Zeolite	(3) Treated by Lime-Soda	(4) Treated by Compound
Calcium carbonate.....	18.20	0.00	3.50	20.50
Calcium sulphate.....	10.35	0.00	0.00	7.23
Magnesium sulphate...	9.51	0.00	0.00	9.51
Magnesium hydrate...	0.00	0.00	0.50	0.00
Sodium carbonate.....	1.00	19.30	1.00	0.00
Sodium sulphate.....	9.26	31.31	31.31	12.52
Sodium chloride.....	0.30	0.30	0.30	0.30
Colloidal matter.....	0.00	0.00	0.00	2.24
Total solids.....	48.62	50.91	36.61	52.30
Incrusting solids.....	38.06	.....	4.00	(39.48)*
Non-incrusting solids..	10.56	50.91	32.61	12.82

* The scale-forming matter and colloidal matter are added to obtain this figure, but it must be remembered that the action in the boiler results in this material depositing as a sludge rather than as a scale.

In examining this table, it will be noticed that treatment by zeolite will completely eliminate the hardness and consequently the scale-forming nature of the water, but the sodium salts increase from 10.56 grains to 50.91 grains, of which 19.3 grains will be sodium carbonate. Lime-soda treatment reduces the scale-forming matter to 4 grains, but increases the sodium salts to 32.61 grains. To achieve this effect with lime soda requires the addition of at least 6.1 lb. of lime and soda to each thousand gallons of the raw water, 3.5 lb. of lime and 2.6 lb. of soda. In using compound, but two-thirds of a pound is added per thousand gallons of raw water, or a little less than one-ninth as much chemicals are added as in the case of the lime-soda treatment. The result is that the hardening salts are deposited as a sludge and the sodium salts are increased to only 12.82 grains.

The question now develops as to whether the precipitated sludge formed with compound treatment is more or less desirable than the sodium salts formed with the other methods of treatment. Sodium salts in the boiler water are dissolved uniformly through the water, and blowing off some of the boiler water allows the removal of but a small proportion of the total amount present. With the compound treatment the hardening salts gradually settle out as a sludge, which can be largely removed from the boiler by the occasional use of the blowoff cock, resulting in a cleaner water as regards total mineral matter left in the boiler water considering both dissolved and precipitated mineral matter. The hard-water analysis used for illustration happens to be one used in large amounts for boiler feed. Both zeolite and lime-soda treatment were tried, but neither proved successful because of the foaming nature of the water thus treated. Compound treatment, by proving successful, clearly refutes the statement that it is satisfactory only when waters of moderate hardness are concerned.

Power Consumption of Small Refrigerating Machines

By John E. Starr

The rapid change in methods of refrigerating from using natural ice to using manufactured ice is nearly complete. In the period from 1904 to 1909 the use of ice-making machines increased by over 80 per cent, in the next five years the increase was 50 per cent, and in the period from 1914 to 1919 the increase was about 25 per cent. The market has nearly reached the point of saturation as far as exchange of methods is concerned, and the continued demand for refrigerating machinery will depend upon the increase of population and increase in use per capita.

During the same period the installations of machines of from 10 to 300 tons daily capacity has been large. In the State of New York, for example, the annual refrigeration output from machines of over 8 tons daily capacity is over ten million tons, while over one million and a half tons of refrigeration is actually performed by machines of less than 8-ton capacity each. The demand for small units has turned the machine manufacturers' attention sharply to this phase of the business, and leaving out the struggle of producing a satisfactory household machine of a capacity equal to 20 to 30 lb. of ice per day, the 200- to 3,000-lb. unit is at the present time given much attention, even by manufacturers who have heretofore been largely concerned in making the larger machine.

The study of the thermodynamics of the small machines presents some phases that, while similar in nature to large machines, differ widely in degree. Production of power on a small scale versus production on a large scale presents the same problems here as in any other class of machinery. The production of power on a large scale and its subdivision and transmission to small consumers, as in the case of our electric companies, has simplified the figuring, but has not leveled the cost of operation of large and small units. Smaller machines still use and probably will continue to use more power per unit of production than larger ones, and the power so used is likely to continue to cost more per unit of power.

It takes more power to compress a pound of ammonia gas in a small apparatus than in a large one because there are more losses por pound in a small machine than in a large one. If we bail water out of a pool with a large bucket that has a small leak, we will empty the pool quicker and easier than if we bail with a small can with a small leak. With water we can stop the leak entirely, but we cannot stop the heat leak in the re-

frigeration plant entirely, as there happens to be nothing that will entirely stop the flow of heat. The percentage of loss on the way from the point where we have received the power to the final point of delivery to the gas, is also necessarily greater in a small machine than in a large one, such as the loss in delivery from the motor shaft to the crankshaft, compressor rods and piston and perhaps reducing gear.

The loss in converting the power delivered and paid for from the wire to the motor shaft also necessarily increases as the machine becomes smaller. A 200-hp. motor might show 92 or 93 per cent efficiency, and a 4-hp. motor might show 75 per cent, while a ¼-hp. motor may have a loss of 50 per cent.

One might pay one cent per kilowatt-hour if he were using 3,500 kilowatt hours per day, while he might have to pay 5 to 7 cents if he were using 10 per day.

The economy of the operation, therefore, does not lie in the cheaper production or utilization of power, but in the fact that in one case the product, refrigeration, is delivered and in the case of ice it has to be delivered in the form of ice, and the cost and waste of such delivery is paid by the user. It often costs more to deliver the medium for taking up heat than to take up heat.

Returning to the strictly thermodynamic aspect of the case, it may be well to inquire into the results practically obtained. The owner of a large machine, when he uses 100 units of power, will pay less per unit than a very small user. Then of that 100 units he will perhaps waste 8 in getting his power to shaft and perhaps more in getting the power from the shaft to the gas. A very small user will buy 100 units of power and pay more per unit than the large user. He may waste and

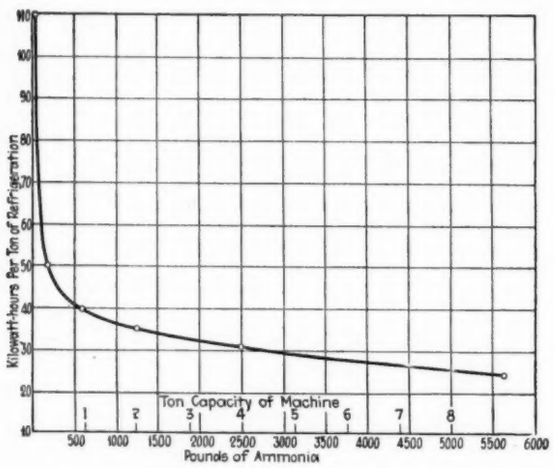


Fig. 1—Kilowatt-hours required by small ammonia compressors

probably will waste 50 per cent of it to get it to the shaft and have 50 units left. He may waste 25 more in getting to the gas and really utilize only 25 units out of the 100 he has paid for. This 25 units, after it has arrived at the gas, has more work to do per unit of production than the large machine, because more gas has to be handled per unit of production.

These losses are pretty well understood and reckoned with in large machines, but are not so closely followed up in the smaller operations. To give a graphic representation of the case there is exhibited by the charts the relation between the power used per ton of refrigeration and the size of the machine.

An evaporating-coil temperature of 11.3 deg. F. suffices for most refrigerating operations. A receiver or condenser presence of something over 100 deg. F. covers nearly all conditions likely to occur. If the ammonia is liquefied at 200 lb. gage and comes to the evaporator at 100 deg. F and is evaporated at 25 lb. gage, each pound will take up 449 B.t.u. As 200 B.t.u. equals one ton, 200 ÷ 459.1 = 0.4356 lb. of ammonia

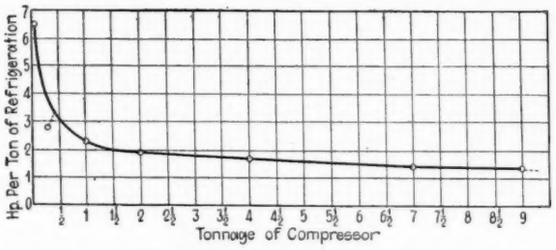


Fig. 2—Horsepower to drive compressors

per minute must be evaporated to produce one ton of refrigeration, or 627 lb. per ton per day. The amount of ammonia per day to be circulated works out as follows:

To produce 100 lb. of refrigeration per day, 31.35 lb.; 600 lb. of refrigeration, 188.1 lb.; 1 ton of refrigeration, 627 lb.; 1½ tons of refrigeration, 941 lb.; 2 tons of refrigeration, 1,254 lb.; 3 tons of refrigeration, 1,881 lb.; 4 tons of refrigeration, 2,508 lb.; 9 tons of refrigeration, 5,643 lb.

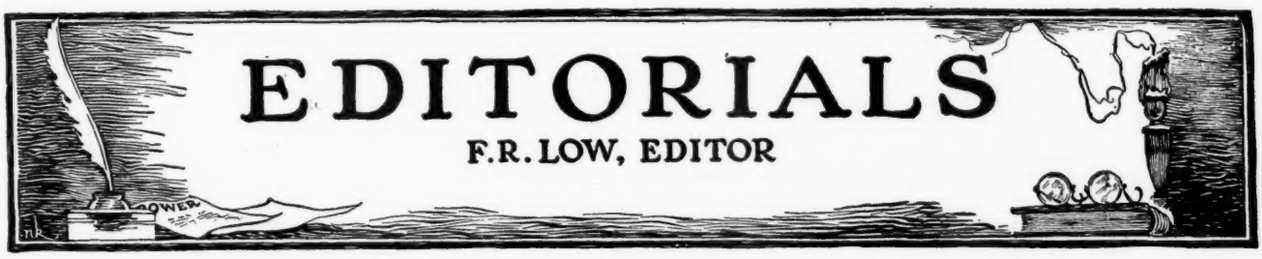
Tests on the actual performance of the nine sizes of machines have been made. Some of them used a fluid other than ammonia such as chloride of ether and sulphur dioxide, but as the amount of work to be done on any gas to produce a certain amount of refrigeration is about the same, the proportionate sizes of the machines and the losses sustained are placed on the basis of ammonia.

In Fig. 1 the figures at the bottom, such as 500, 1,000, etc., represent different weights of ammonia that the machine handles per day. The notations of 1 ton, 2 tons, etc., are the capacities of the machines on which actual tests have been made; the figures at the left are the kilowatt-hours per ton and include all losses incident to a well-designed machine, including motor losses.

It will be noted that at about two tons capacity the rate of use of power per ton of refrigeration begins to increase rapidly as the machine becomes smaller. This is due to a considerable extent to the decreasing efficiency of the motor as it gets smaller. On the very small machine the hope for improvement lies in the lessening of the loss in transmission and the reduction of heat slippage, both items being as a rule large and both susceptible of improvement.

In Fig. 2 is given the horsepower required to run a compressor where delivering refrigeration at various rates of duty.

The belt conveyor system of the plant of the Beechbottom Power Co., at Power, W. Va., as described in the Oct. 16, 1923, issue, has up to the present time transported approximately two million tons of coal. This plant contains six 30,000-kw. units and requires about 2,500 tons of coal per day. The conveyor system is capable of delivering 500 tons per hour, contains a large storage for coal as well as devices for weighing, sorting, crushing and spraying.



Power for Value Received

MAINE'S curiously obstructive attitude toward the exportation of hydro-electric power is beginning to create discussion of this policy in the Pine Tree State itself. Clarence G. Stetson, of Bangor, a former associate of Secretary Hoover, has taken up this issue within the last year in some very suggestive addresses before Maine citizens; the Lewiston *Journal* has opened its columns to opinion on this topic, and recently Guy E. Tripp talked very frankly about the superpower problem and Maine's relations to it in an address at Auburn. *Power* has discussed the question editorially within the last few months, and the recent New England power resources report of the Associated Industries of Massachusetts emphasized the burden this policy is putting upon the Northeast. It is to be hoped that the campaign of enlightenment now under way will effect a complete change of popular sentiment in due course. The opinion that Maine should clutch its water powers to its bosom lest some bogy-man from the south seize them and carry them away is fundamentally emotional.

The idea is advanced in some quarters that Maine would lose everything if its water powers were interconnected with outside states. On the contrary, not only would Maine receive "good" money for exported power and additional taxes from the generating and transmission plant required to produce and ship out the surplus, but it would be benefited in times of water shortage by return power from the systems of near-by states. Something like fifteen years' experience with the non-exportation law has failed to produce the local industrial development that some like to picture as dependent upon keeping this power at home, and if Maine is to keep up with the march of progress, she will do well to repeal an act that is apparently a stumbling block to her prosperity.

Tell the Public What Ventilation Means

TREMENDOUS strides in the science of ventilation are characteristic of the last few years. Nevertheless, with the overcrowding frequently encountered, it is not difficult to find many instances where conditions are equally as bad or worse than those of a previous era.

The aim of the ventilating engineer includes not only comfort with regard to temperature at a minimum of expense, but which is far more important, an atmosphere containing a normal amount of oxygen, free from dust, bacteria and poisonous gases. In short, human health and well being are to be protected. Since improvements relating to sanitation do not primarily possess the appeal of those representing comfort or luxury, they may perhaps be more difficult to introduce and require more intensive education of the public.

Experimental work conducted along the lines of heating and ventilating has achieved admirable results as to the control of humidity with respect to human comfort, and also the more efficient means of utilizing heat. Research work will undoubtedly be further prosecuted, so that as a result human beings may benefit more, as there is ample room for improved health conditions. Investigations recently reported show that between the closing of windows in the fall and the thorough ventilation of late spring, human illnesses are much more prevalent.

Healthful ventilation is more naturally desired in better classes of buildings, such as hotels or modern theaters, than in those devoted to business, where comfort is not such an important background. It is highly probable that a study of the beneficial effects of a well-conditioned atmosphere would show a commercial justification in the increased yield from human effort, whether this represents purely physical labor, that classed as brainwork, or the activities of clerks behind bargain counters.

In view of the general benefits to the public and in justice to the organizations who have backed these movements and the large number of manufacturers interested, the research results of the ventilating engineer should be brought home to the possible consumer, especially where the advantages are indirect rather than those pertaining to immediate comfort or convenience.

Oxygen and Pipe Corrosion

IF OXYGEN is dissolved in water and iron is then introduced, corrosion or rust appears to be a simple and natural result, since iron oxide is ordinarily regarded as rust, and with free oxygen in solution this would be expected. The actual mechanism of corrosion, however, as illustrated elsewhere in this issue, in connection with a study of corrosion in heating systems, shows that the chemical actions are far different. What is called iron rust actually is not iron oxide, but iron hydroxides such as $Fe(OH)_2$ and $Fe(OH)_3$. These are highly insoluble in character, and therefore precipitate readily when formed. Upon sufficient application of heat they turn into iron oxide.

It appears that corrosion is due primarily to an electric current and the dissolved oxygen assists in forming ferric hydroxide, $Fe(OH)_3$ and also in removing the hydrogen gas which tends to collect at the negative poles and cut off or insulate against the electric current. Oxygen is not therefore primarily responsible for corrosion, but is somewhat of a secondary agency in the actual process.

An interesting sidelight is contained in an article, "A Paradox in Corrosion," by Ulick R. Evans, in the June 16 issue of *Chemical and Metallurgical Engineering*, describing that which takes place in metals covered by a saline solution.

When air is bubbled against one end of a metal in such a solution, the oxygen thus supplied does not attack the end of the metal against which the air is played. As a matter of fact corrosion takes place entirely on the other areas. This roughly indicates that the combination of iron and oxygen to form iron oxide, as the uninitiated might suppose, is not the fundamental chemical action.

On the contrary it bears out the theory that the oxygen promotes corrosion by uniting with the hydrogen that forms on the cathode or negative surfaces. In this case the bubbling action would tend to clean the cathode by the removal of the hydrogen. This was further investigated by protecting one end of the metal with a porous covering so that the oxygen could not get near the metal. The result was that corrosion was most active in this covered portion entirely protected from oxygen. It appears that cracks or fissures started by corrosion tend to continue this action and thus become deeper and deeper. A honeycombed structure is thus produced.

Pitting of Hydraulic Turbine Runners

CORROSION is one of the greatest enemies that has to be contended with in the use of metals. It causes the power-plant engineer as well as other serious difficulties and expensive repairs, not considering the reduced efficiency due to equipment operating with corroded parts. Although a great deal of study has been given to the cause and prevention of corrosion the problem is still open to a wide diversity of opinion. This is to be expected since corrosion occurs under so many and varied conditions. Experiments carried on with liquids at rest have given diametrically opposite results to what occurred where turbulence was present. As an example of this, experiments conducted with still water showed that a reduction of pressure on the liquid decreased corrosion, where with the water in motion the opposite was true. So it has been that where experimental data were checked against conditions existing in practice, frequently one apparently contradicted the other and led to confusion. However, as the subject becomes better understood the reasons for these contradictory results are becoming apparent.

There has been much mystery and misunderstanding surrounding the pitting of turbine runners. With two runners installed in apparently identical setting, one would pit and the other be practically free from this action. A change in design in one installation has overcome corrosion, while in others the change has had little or no effect. These effects can now be apparently accounted for in terms of total draft head as given in the 1924 report of the Hydraulic Power Committee of the National Electric Light Association, an abstract of which was published in last week's issue on page 31. Although the report is only tentative, the evidence that the primary cause of pitting of turbine runners is due in a large measure to excessive draft head is so conclusive as to leave little room for doubt.

The actual cause of corrosion is, as has been held for a number of years, chemical or electrochemical, due to the water leaving the surface of the bucket and causing a partial vacuum in which oxygen is released from the water and attacks the metal. In all of the seventy different wheel settings investigated, serious pitting did not occur with draft heads below twenty-four feet. With few exceptions, and these were small wheels, were runners free of pitting above twenty-four feet total draft head. Below eighteen feet total draft head all runners were practically free of pitting. These results are apparently substantiated in a case where a plant, not referred to in the report, operated for over a year at greatly reduced head due partly to high tailwater. In this installation serious pitting of the runners was expected but did not occur. If these runners had operated under full draft head, the pitting might have occurred, since experience has shown that a matter of two or three feet may make all the difference between a runner that pits badly and one that is free of corrosion.

This report, although probably not covering all causes that tend to produce pitting, has established a danger line; if the designer passes this line, pitting may be expected. It also provides a yardstick for the operator whereby he may check up and see how closely the draft head on his turbine approaches the line where difficulty may be expected.

Makeshift vs. Permanent Repairs

IN THE stress of modern plant operation temporary repairs are at times inevitable. The cost of keeping on hand complete duplicates of equipment which at some time may suffer breakdown runs into such heavy figures in proportion to plant investment that allowance for the constructive resourcefulness of the operating personnel is essential. The field of plant maintenance is altogether too large to narrow down routine operation to regular starting and stopping of equipment, supplemented by mere substitutions of spare parts in case of trouble.

During periods of satisfactory operation plant engineers will do well to make a closer study of the general and specific problems of maintenance. Adequate preparation against protracted shutdowns involves a study of the time required to manufacture and ship spare parts on rush order, the overhead costs of holding "key" parts which cannot quickly be duplicated in stock, the growth of depreciation and obsolescence in equipment, and the possibilities of making up substitutes for emergency work. Too little care has been used in the past to record dimensioned sketches or, better, to file complete working drawings of parts put together under stress of operating trouble. After the emergency is past, the operating engineer should capitalize to the full his experience in meeting it, and this calls for suitable records that will save time in case the trouble is repeated—and in power-plant service accidents and other untoward events do frequently happen twice in the same place and manner despite all the efforts to the contrary.

This study of maintenance will show when it will pay to combine permanent repair work with temporary methods. However, a vigorous policy on behalf of replacing makeshifts by permanent construction should be urged by the man responsible for plant service. If he cannot get his superiors to authorize such improvements, he can at least go on record in behalf of thorough engineering and at every reasonable opportunity seek to get rid of temporary expedients that lack the reliability and efficiency which the load responsibilities of the installation justify.

Comments from Readers

Diagram from a Forty-Year Old Corliss Engine

The indicator diagrams from a forty-year old Corliss engine in the May 6 issue, show very good performance for a slow-speed, single-eccentric non-condensing unit.

A little improvement in the valve setting might be made by advancing the eccentric and thereby increasing the lead on both ends, to obtain an early initial pressure at the beginning of the stroke. A little more compression might also be given the crank end by adjusting the exhaust rod. The depression on the steam line of the crank end and also that on the expansion line are in my opinion due to vibration of some parts of indicator. The cutoff as shown is about 18 per cent of the stroke, which would indicate that the engine had a light load at the time the diagrams were taken. A full load should show about one-half cutoff, or 50 per cent of the stroke. CHARLES W. ROOS.

Staten Island, N. Y.

In my opinion the diagrams show excellent performance for an engine of that age and also speak well for the operator.

In criticizing the setting of the valves, I would suggest giving the crank-end steam valve a little more lap and closing the head end exhaust valve a little later, also advancing the eccentric so as to get the same admission line on the head end as is shown by the crank end. As far as economy goes the change would not make much difference, but it would cause the engine to run a little smoother when picking up a heavy load.

It might be interesting to show another diagram from the engine after a change has been made in the valve setting as outlined in the foregoing and when carrying a heavier load. HARLEY ATKINSON.

Gothenburg, Neb.

Developed Special Water-Rate Test Last Fall

I read with profound interest F. S. Youtsey's article "Testing Steam Turbine and Barometric Condenser," in the June 17 issue. I am glad to note that someone else has stumbled over the truth I have been endeavoring to prove for some time past.

Last fall I was confronted with the task of ascertaining the water rate of several Corliss cross-compound engines served by barometric condensers. Numerous tests had been conducted on those engines prior to that time by the official A. S. M. E. method, and I was surprised to find that the results of those tests were neither reasonable nor consistent and the expense of conducting them appalling.

The works manager suggested Prof. J. Paul Clayton's method (A. S. M. E. *Trans.*, 1912), and with two assistants I spent five weeks' time transforming indicator cards into logarithmic diagrams. The results appeared encouraging at first, but when a sufficient number of cards had been analyzed and the results tabulated, the latter were erratic and the method was abandoned.

During one of the conferences on the subject the consulting engineer remarked: "If we could measure the quality of the steam entering the condenser, we could determine the water rate of the engines by means of a simple computation." I set out to devise a method for measuring the quality of steam in a vacuum, but soon realized that it was neither practicable nor necessary for the purpose.

A heat-balance-chart showing graphically the distribution of the B.t.u. entering the throttle (which Mr. Youtsey terms *A*, *B* and *C*) convinced me that by making an assumption in one of the terms which is of a "secondary" magnitude (and a 100 per cent error in the assumption will yield an error in the results well within the limit of the accuracy required, as Mr. Youtsey correctly pointed out), an expression is obtained for the water rate of steam prime movers in terms of quantities that are easily and accurately measurable.

After considerable study and research I reduced the matter to very simple terms and named it "the heat-balance method for testing steam prime movers."

I conducted numerous tests using the heat-balance method and varying the load on the engines between 700 and 1,900 i.hp., the amount of injection water between 29 and 197 lb. per pound of steam and the temperature rise of the injection water between 4.5 and 30 deg. F., and was amazed at the sensitiveness of the method, the consistency and reasonableness of the results.

Thinking that the matter might be of interest to other members of the engineering fraternity, I prepared a paper on the subject and submitted it to one of the engineering associations. Three months later the paper was returned to me with eleven comments. I checked and rechecked the matter in the light of the criticism offered and came to the conclusion that the latter "wouldn't hold water." So I submitted the paper to another engineering association. The paper was shortly afterward returned to me, rejected, fifteen reasons being cited.

The heat-balance method for testing steam prime movers which I developed and used successfully is substantially the same as that used by Mr. Youtsey, except that I use instantaneous measurements instead of hourly quantities, I measure the condenser discharge instead of the injection and use charts to facilitate computation.

By means of the heat balance method for testing steam prime movers, the water rate, the ratio of injection water and the quality of the exhaust steam of any kind of a steam prime mover equipped with any kind of a condenser may be accurately determined in less than two minutes' time at no expense whatsoever, except the original cost of installation of a weir in the condenser discharge well. I shall be pleased to prove it to anyone interested. E. OGUR.

New York City.

Computing Stoker Guarantees

Referring to H. F. Gauss' articles on "Computing Guaranteed Stoker Efficiency," in the May 20 and 27 issues, the general scheme is much more rational than the average method of guessing what your competitor is going to do and going him five per cent better, but there are some points on which I think proof is required to sustain Mr. Gauss' figures.

The first of these is in the table of unaccountable losses in per cent of heat in fuel as fired (May 27 article). In this, both the radiation and hot-ash losses are made to increase quite materially as a *percentage of the heat* of the fuel at the higher ratings. Now it is generally recognized that neither the furnace nor the flue temperature increases by a particularly noticeable fraction of the difference between themselves and room temperature at the higher ratings, so that *a priori* there is no reason to expect more than a moderate increase in the actual amount of radiation at higher ratings, and since this increase will be at a less rate than the heat developed in the furnace, the result will be a diminishing percentage. This is in accordance with experience, which shows that radiation losses are lower with large boilers and at high ratings.

For the same reason, since the fire temperature does not triple in raising the rating from 100 to 300 per cent, it is hard to see why the heat carried to the ashpit by the hot ashes should do so, particularly as provision is made elsewhere for calculating the losses due to unburned carbon in the refuse. From the generally accepted constants the figure of even one per cent loss due to hot ashes seems high, for taking a specific heat of 0.12 and even 2,500 deg. F. temperature above the boiler room, with a 10-per-cent-ash coal of 13,500 B.t.u., this would only mean a loss of

$$\frac{2{,}500 \times 0.12 \times 0.10}{13{,}500} = 0.22 \text{ per cent,}$$

which is usually and justifiably neglected. On the allowance of one per cent for "blowing down and leaks," it must be remembered that for the standard code method of boiler testing with weighed water, blow-down, if permitted, and leaks will tend to raise rather than lower the apparent efficiency.

Another item, which may possibly be a confusion of terms, though as written it does not seem to be covered, is the latent and sensible heat of the moisture formed by the hydrogen which does not appear as moisture in the proximate analysis nor as available hydrogen in the ultimate; that is, the hydrogen which forms what is sometimes known as water of constitution. In some coals, particularly crop coals or Western coals in the range approaching sub-bituminous, this is a considerable quantity, and in my opinion the process of figuring would be simplified by taking the ultimate analysis on an as-fired basis and treating all the hydrogen alike.

One item that has been entirely neglected, is the loss of unburned combustible gases up the chimney, and while it would perhaps be too much to expect a stoker manufacturer to admit such a thing could occur with his equipment, it is by no means unknown and is perhaps camouflaged by the increases shown in radiation and hot-ash losses at the higher ratings.

Considering the purpose for which the calculations are to be used and the uncertainty of the fuel, air supply or boiler-flue temperature corresponding exactly to specifications, a much simpler method of calculating flue losses is to base the air supply, as Mr. Gauss has done, on the heating value of the coal, but to follow this to its logical conclusion and express the loss as a direct function of the difference between boiler-room and flue temperatures. From a large number of heat balances worked out from the ultimate analysis of the fuel, it was found that the loss due to the products of combustion alone—that is, the air which has actually combined with the fuel in the gaseous form, as expressed by Mr. Gauss' $(A_t + C)$ is 0.021 per cent for each Fahrenheit degree of flue temperature above that of the boiler room. Using Mr. Gauss' symbols and expressing all losses in percentages, we have:

Stack loss in products of combustion =

$$L_{spc} = 0.021\ (T_f - 70)$$

Stack loss in excess air = L_{sa} =

$$0.017\ (T_f - 70) \times \frac{\text{per cent excess air}}{100}$$

Total dry-gas stack loss = $L_s = L_{spc} + L_{sa}$

Mr. Gauss sums up the whole situation in his closing paragraph, for a great deal more depends on the engineer who is writing the guarantee forming an accurate picture of the conditions to be met than on the most painstaking figuring from uncertain assumptions.

New Haven, Conn. H. D. FISHER.

H. T. Gauss, in an article entitled "Computing Guaranteed Stoker Efficiency," in the May 20 issue, gives formulas for computing some of the boiler losses. Curves and equations are shown for use in calculating the amount of dry air required for combustion with any given value of CO_2. The following equation is given for determining the heat loss in the hot flue gases:

$$L_s = (T_f - 70)\ (A_a + C)\ 0.24$$

where

L_s = Heat carried up the stack by flue gases;
T_f = Temperature on stack side of damper;
A_a = Pounds of air supplied per pound of coal;
C = Combustible per pound of coal;
0.24 = Specific heat of flue gases.

Mr. Gauss evidently intends this equation to represent the loss resulting from the heat carried away in the dry flue gases. To be correct, the amount of moisture formed in the burning of the hydrogen should be subtracted from the sum of air supplied for combustion and the combustible per pound of coal. The correct equation would be:

$$L_s = (T_f - 70)\ (A_a + C - W)\ 0.24$$

in which W equals the weight of water formed in the burning of the hydrogen in the coal.

Although the error resulting from this omission is not serious, it being a maximum of about 0.5 per cent on the boiler efficiency, it is thought well to point out why this equation will not give a result that will check with those found by the use of the heat-loss equation given in textbooks on the subject.

Taking the assumption that Mr. Gauss uses in working up his example: $T_f = 550$ deg.; $C = 0.8$ lb.; $A_a = 14.63$ lb.; with 0.8 lb. combustible per pound of fuel and 0.039 lb. hydrogen per pound of combustible, the percentage of hydrogen in the fuel is 3.12 and the carbon is approximately 77 per cent. The loss due to the heat carried away by the dry chimney gases is $(14.63 + 0.8 - 0.28)\ (550 - 70)\ 0.24 = 1{,}745$ B.t.u.

Pittsburgh, Pa. J. E. RICHARDSON.

American and European Hydraulic Turbine Practice

It would appear that the controversy that has arisen regarding the subject of American and European hydraulic-turbine practice is somewhat difficult to terminate. Since my last communication, which appeared in the June 10 issue, a further development has taken place which throws an interesting sidelight on one of the points previously brought out. I refer to an article by Kurt Pantell, of Charlottenburg, which appeared in the *Zeitschrift des Vereines deutscher Ingenieure* for April 12, 1924.

In my last letter to *Power* I mentioned the general attitude displayed by some European writers and the impression still quite prevalent in Europe that American engineering is necessarily inferior and unscientific, and as an example I mentioned the contention that has been repeatedly advanced for many years by certain European writers that American turbine tests are unreliable and that all American efficiencies must be discounted. Mr. Pantell's article exemplifies this attitude.

Based on the information which Mr. Pantell has obtained from Norman R. Gibson's paper presented to the American Society of Mechanical Engineers on "The Gibson Method and Apparatus for Measuring the Flow of Water in Closed Conduits as Applied in Testing the Efficiencies of Waterwheels in Hydro-Electric Power Plants," Mr. Pantell has described this method for the benefit of his German readers and has then undertaken to point out certain errors which he believes he has discovered in this method, and arrives at the conclusion that the 93 per cent efficiency secured in the 37,500-hp. turbines of the Niagara Falls Power Co. is subject to an error of 7 per cent. Without attempting to verify his conclusions in any way, Mr. Pantell has proceeded to publish his criticism with the natural result that the matter has already been given general publicity in Europe as reflected, for example, in the May 15 issue of *Die Wasserkraft*, which, in reviewing Mr. Pantell's article, refers to "proof of an error in the measurement of the turbines of the Niagara Falls Power Co. No. 3 with alleged 93 per cent efficiency amounting to about 7 per cent of the water quantity."

It is interesting to note that Mr. Pantell's deduction results from a simple error in one of his equations. He finds no fault with the method of plotting the curve of pressure variation, but believes he has discovered an error in the plotting of the base line representing the penstock pressure under constant-velocity conditions. In endeavoring to compute the position of the base line, Mr. Pantell takes the square of the difference between the initial velocity at the time the measurement begins and the velocity at any instant, instead of using the difference of the squares of such velocities. In other words, his alleged correction of 7 per cent is due to an incorrect formulation of a basic hydraulic law. The point in question is so simple that any hydraulic engineer analyzing the matter will readily detect it.

The thing that impresses the writer is that Mr. Pantell should not have appreciated the fact that the tests in question were the result of long and careful study by the highly experienced engineering organization of one of the largest power companies in the world; that the method has been accurately checked by volumetric measurements and by comparison with other methods of measurement; that it has been applied in tests of many plants and has been checked up and approved by many other engineers connected with different power companies; and therefore that if a systematic error of any such magnitude as 7 per cent were inherent in the method, it is of the highest degree of improbability that it would have failed of detection.

In view of these facts one would think that the appearance of an error as great as 7 per cent would have prompted Mr. Pantell to have someone check up his calculations before putting anything in writing. It would certainly be an absurdity if American turbine practice should be subjected to strictures based on this oversight.

H. BIRCHARD TAYLOR, Vice-Pres.,
Wm. Cramp & Sons Ship & Eng. Bldg. Co.
Philadelphia, Pa.

Will Changing the Connections to the Trap Improve Its Operation?

Although considerable discussion has taken place on the article by B. J. Van Keehern in the Dec. 4, 1923, issue entitled "Will Changing the Connections to the Trap Improve Its Operation?" I should like to add a few comments.

Referring to the illustration given in Mr. Van Keehern's article, if the drain connection *B* prevents the water from flowing readily through the connection *A*, it indicates a drop in pressure in the separator. Lowering the trap 4 or 5 ft., or placing it on the engine-room floor level and running the drain connections separately to the inlet of the trap should remedy the trouble.

With further reference to the articles by W. A. Vedder and B. W. Hay on this subject in the April 1 issue, this type of trap needs no equalizing pipe, and if one were installed, even with flexible connections, it would seriously interfere with the proper operation of the trap. A bypass is all right, but it takes only about twenty minutes to regrind the valve, and a bypass valve on a trap is a temptation for some engineers to leave open, in place of making necessary repairs.

I prefer the tilting type of trap for high pressure drains for the reason that the capacity of any trap depends to a large extent upon the size of its valve, and in the case of bucket or float traps, which have restricted orifices, the capacity is cut down, and on account of high velocity, the valve cuts out in a short time.

Tilting traps similar to the one in question can take care of large slugs of water if they come over. The manufacturers' catalog rating on capacity at 150-lb. pressure for ½-in. trap is 5,160 lb. per hour, ¾-in. trap 10,320 lb., and the 1-in. trap 17,200 lb. per hour. The area of the valve on this trap is greater than the inlet pipe to the trap, and for this reason the velocities are not high and the valves do not cut out.

Referring to the article by Mr. Hay, a new valve and disk would be less expensive than fitting the piston with rings. Generally, when a trap hangs up, it is due to using the wrong packing in the trunnion stuffing boxes. If this is not the case, moving the yoke back a short distance will materially increase the leverage and prevent the trap from hanging in a partly open or partly closed position.

At the plant where I am employed, we have a ½-in. tilting trap draining a 9-in. receiver separator. This trap has been in service four years, and we have reground the steam valve only three times. It has given excellent service at all times.

G. J. BULLISH.
Grand Rapids, Mich.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Internal Combustion Cycle

What constitutes a cycle in an internal-combustion engine? *L. A. W.*

The term cycle means a complete course of operations of some kind, returning into itself and restoring the original state. The term "engine cycle" is applied to the series of events which are essential for the conversion of heat into work. For instance, the Otto internal-combustion engine cycle requires four strokes of the piston that comprise five events which are: suction, compression, ignition, expansion and exhaust. An internal-combustion engine operating in this manner is said to work on the four-stroke Otto cycle.

Variation of Water Level in Gage Glass

What is the cause of continual rising and falling of water level shown in a boiler gage glass? *W. N. F.*

The surging shown in the gage glass is due to rising and falling of the water level in the boiler over the point where the water column is connected to the water space of the boiler, resulting from oscillation of the water, induced by its circulation or activity of boiling. Surging in the gage glass also may be caused by variation of pressure in the steam connection of the water column, due to drafts of steam taken out of the boiler near the point where the steam connection is made for the water column.

Load Taken by Induction Motor Operating in Parallel with Waterwheel

A three-phase induction motor is belted to main lineshaft, which is connected to waterwheel. With the switch to the motor closed and the waterwheel running, what percentage of energy is supplied to the lineshaft by the motor? *W. E. F.*

The amount of energy taken by the induction motor will depend on the adjustment of the waterwheel governor. With this arrangement the governor adjustment should be such that the motor will supply only the energy not available from the water power. There are two conditions that may exist—one is where there is more than sufficient water to load the wheel up to its maximum capacity, and the other where there is a limited amount of water. Where there is an excess of water, the governor should be adjusted so that the waterwheel will carry its maximum load. On the other hand, where there is a limited amount of water—that is, not sufficient water to operate the wheel all the time at its maximum load—the waterwheel governor should be so adjusted that the wheel will take just sufficient water to allow the head to be maintained at a maximum, as under this condition maximum power is obtained for the amount of water available. Adjusting the governor so as to increase the speed of the wheel will cause the waterwheel to take more of the load and the induction motor less. The reverse will be true if the governor is adjusted on the waterwheel so as to decrease its speed, as then the motor will take more load and the waterwheel less. Where the forebay has sufficient capacity to be used for storage as during nights, Sundays and holidays, then the forebay should be drawn down during working hours to provide storage without waste of water when the wheel is out of service.

Operation of Centrifugal Feed Pump

Is the necessary power required for driving a centrifugal less when the discharge valve is shut than when the discharge valve is open and delivering water, provided the speed is maintained constant; and is it better practice to reduce the discharge by throttling the intake, or the discharge side of the centrifugal? *W. A. S.*

Less power is required when the discharge valve is closed than when open, since, when partly closed, less work is performed in lifting and forcing water, and with lower velocity there is less loss of power in overcoming pipe friction. It is better practice to regulate the flow on the discharge side of the centrifugal. However, a centrifugal feed pump should not be operated with the discharge valve entirely closed, as the heat produced by churning the water by the impellers may so raise the temperature of the water that in a short time it becomes hot enough to vaporize and allow the pump to become steam or vapor bound, causing cutting or siezing of the bearings. A bypass should be arranged in the pipe lines so that when it becomes necessary to operate a very low discharge capacity, the bypass can be opened and prevent this difficulty.

Setting Valves of Buckeye Engine

What is the method of setting the main and cutoff valves of a Buckeye engine? *R. J. W.*

Remove the valve covers, so the valve edges may be seen or felt with a long piece of flat wire. It is to be borne in mind that the exhaust is from the ends of the main valve and that it takes steam from the center, so that when opening, the valve is traveling in a direction opposite to the motion of the piston; also that there is indirect motion of the rocker from the riding eccentric for movement of the cutoff valve. First adjust the travel of the rocker so the main eccentric rod rocker pin swings equally each side of a plumb-line over the center line of the main rocker pin. This may be tested by revolving the main eccentric on the shaft and correcting any inequality by adjustment of the length of the main eccentric rod.

The next step is to see that the main valve opens the same for both ends. For that purpose place the

main eccentric at its greatest throw forward and note if there is a full port opening, then place the eccentric on its opposite center and note if there is a full port opening, and adjust the eccentric-rod length so the valve will be opened the same amount with the main eccentric on first one center and then the other. Any adjustment of valve rod length thus needed is made by slipping the clamp on the valve rod where connection is made from the rocker arm to the valve stem. Next place the engine on dead center and revolve the main eccentric in the direction of rotation of the shaft, following the crank until the desired lead is obtained on that end. When the engine is placed on the opposite dead center, the lead should be the same. If it is not, equalize the lead on the valve rod. The lead to be given varies from $\frac{1}{16}$ in. for a 10-in. cylinder to $\frac{1}{4}$ in. for a 24-in. cylinder, increasing this about $\frac{1}{16}$ in. for high-speed engines.

Next set the cutoff valve. When the rider eccentric and main eccentric are placed together, the cutoff valve should rest square over the ports. When the engine is on dead center, the governor wheel should be at such a position on the shaft that the throw of the eccentric is exactly in line with the crank, on account of the reversing motion of the indirect rocker. With the governor wheel properly set on the shaft, block out the governor half way, slowly turn the engine over in the direction of rotation and note when the valve is just closed on the end that should take steam, and mark on the guide the distance the crosshead has traveled. Then turn the engine to the opposite dead center and mark on the guides the distance the crosshead has traveled when the valve closes in the stroke from the end. If the distances are not alike, find the difference between the cutoffs and, turning the engine forward, put the crosshead at a point representing one-half this difference and reset the cutoff valve so it is just closed. If all adjustments have been correctly made, the cutoff then should be the same for both ends.

Elevator Goes up with the Controller on the Down Position

What causes an elevator to take an upward motion when the controller handle is pushed over to the down-motion position? *A. A. A. R.*

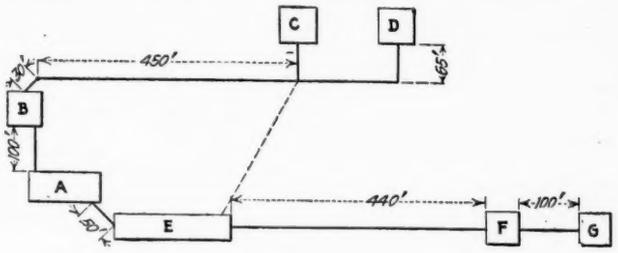
If the wiring is correct, the cause of an elevator taking an upward motion with the controller in the down position will depend upon the type of machine. If the motor and controller have been disconnected and then reconnected incorrectly, then, of course, the trouble is in the wiring. Assuming that the wiring has not been interfered with and that the machine is of a semi-magnetic control type with a mechanical brake, then there are two conditions that could cause the trouble on a spur-geared type machine. First, with the car over-counterweighted, the operator may pull the cables to a position where the brake is released, with power not cut into the motor. In that case the counterweight would be free to run the car in the up direction. Under similar conditions, but with the power circuit open, if the operator pulls the car cable to the down-motion position, the brake would be released, but there would be no power to the motor to drive the car in the position it should go, and it would be carried upward by the counterweights going down. These conditions would also be true for a worm-geared machine, but in this case the friction of the worm gear is generally sufficient to prevent movement of the car. If the car were loaded to a point where it was heavier than the counterweight, it would take a downward instead of an upward motion under the foregoing conditions.

In the case of an elevator with a magnet brake, the only case where the conditions referred to in the question could apply would be where the motor circuit was opened in such a way that power could not be supplied to the motor, but the brake coils could be energized and release the brake. In such a case on a spur-geared machine, where the counterweights are heavier than the car and its load, the car would move in an upward direction. However, this condition is remote.

Size of Generator for 6-Hp. Gas Engine

The diagram gives an idea of the arrangement of a number of buildings, situated on an island, which it is intended to light with a small electric plant provided it can be operated by means of a 6-hp. gasoline engine installed in one of the buildings. The inside and outside wiring is made and in good condition. These buildings have already, with many others, been lighted by a large plant which was closed lately. Has a 6-hp. stationary gasoline engine the capacity required to drive by means of a belt, a direct-current generator to supply the current to light the buildings shown on the diagram, which have a total of ninety 40-watt lamps? *J. E.C.*

In figuring the problem, first consider the load. This consists of ninety 40-watt lamps, or a total load of



A, B, C, D, E, F and G represent buildings to be supplied with current

$90 \times 40 = 3{,}600$ watts. The engine is rated at 6-hp. and as one horsepower is equivalent to 746 watts, the engine has an equivalent rated output of $746 \times 6 = 4{,}476$ watts. If a 4-kw. generator is used, it will have an efficiency of about 85 per cent, therefore at full load the machine will require an input of $\frac{4{,}000 \times 100}{85}$ = 4,706 watts, which is practically the rating of the gas engine. It is doubtful if the 90 lamps will ever have to be used at the same time. Therefore, a 6-hp. gas engine driving a 4-kw. generator will have ample capacity to take care of the load.

If convenient to do so, it would be advisable to install the gas engine in one end of building *E*, and from this run a line to buildings *C* and *D*, as shown by the dotted line instead of from building *B* as shown on the diagram. This arrangement would put the load on the system on three circuits of about equal length, and should give a better equalization of the voltage over the system.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications, and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Can Flue Loss Be Eliminated?

EVERY engineer knows that much heat is lost up the stack due to the fact that from 15 to 25 tons of hot gases pass to waste for every ton of coal fired. The possibility of salvaging some of this heat has been prominently before the profession for many years.

Except for the relatively small waste due to incomplete combustion the loss in the chimney gases occurs in two ways only—the heating up of dry gases and the evaporating and superheating of moisture. The dry combustion products consist almost entirely of the three gases nitrogen, oxygen and carbon dioxide. The moisture comes from three sources—the original moisture of the coal, that produced by the burning of the hydrogen and that carried by the air. The second source is the most important.

Two Ways to Reduce Loss

There are, in general, two ways of cutting down the chimney loss. One is to reduce the weight of products from the combustion of one ton of coal; the other is to reduce the temperature at which the products leave the boiler.

Taking up first the question of reducing the weight of products, it is evident that practically nothing can be done to change the weight of moisture or carbon dioxide[1] in the combustion products from one ton (or one pound) of coal.

The only practical possibility of reducing the weight of combustion products is found in reducing the weights of oxygen and nitrogen. Theoretically, the oxygen can be reduced to zero. Practically, on account of imperfect mixing in the furnace, some excess oxygen must always be present if the coal is to be completely burned.

From the point of view of heat wasted the most important substance in the combustion products is nitrogen. Nitrogen is 77 per cent of the air by weight, so that each part (by weight) of oxygen supplied for combustion carries with it $\frac{77}{23} = 3\frac{1}{3}$ parts, approximately, of nitrogen. Dividing the oxygen supplied into two portions, that actually entering into the combustion process and the excess that passes through the furnace without chemical change, it is seen that the nitrogen attached to the former cannot practically be eliminated.

The second portion of nitrogen, that attached to the excess oxygen, is eliminated in proportion to the reduction in excess oxygen. Every pound less of oxygen used takes from the flue gas not only one pound of oxygen but also $3\frac{1}{3}$ lb. of nitrogen. In other words, it means $4\frac{1}{3}$ fewer pounds of air passing up the stack.

The saving by reducing the amount of excess air is practically unaffected by the design or condition of the boiler proper, depending almost entirely upon the kind of fuel, kind of grate or stoker, control of draft over the fire, handling of the fuel bed, construction of the furnace and tightness of the setting up to the point where the gases leave the last pass.

As has already been suggested, there is a definite limit to the saving possible by cutting down the weight of gases. Under the best conceivable conditions the gases contain, either in their original form or in new combinations, all the carbon, hydrogen and oxygen in the coal plus all the oxygen needed to burn the coal, together with the nitrogen that goes with this oxygen. The minimum possible weight of combustion products is about ten times that of the coal burned in the case of a fuel having a calorific value of 12,000 B.t.u. per pound. For other heating values the weight of gases is about in proportion.

The only other method of cutting down the flue losses is to reduce the temperature of the stack gases. Here there is no theoretical lower limit. Practically there is, for any given plant, a certain point below which it would not pay to reduce the flue temperature. If the gases could be brought to room temperature before entering the stack, the stack loss would be reduced to zero regardless of the amount of excess air used. This condition, which cannot practically be attained in any kind of installation, is also theoretically impossible of attainment in a simple boiler the last pass of which contains boiling water. The boiling water obviously cannot cool the gases below its own temperature, which is that of saturated steam at the boiler pressure.

These limiting temperatures for a few typical boiler pressures are shown in the accompanying table.

LOWEST POSSIBLE FLUE TEMPERATURES IN A SIMPLE BOILER

Steam Pressure Lb. per Sq.In. Gage	Temperature, Deg. F.
5	228
50	298
100	338
150	366
200	388
300	422
400	448
500	470
600	489
800	521
1,000	547

These are limits in much the same sense that limits are used in mathematics—something to be approached but never quite reached this side of "infinity." That is, a boiler would require an infinite amount of heating surface to cool the flue gases down to the temperatures shown in the table.

Take the case of a horizontal water-tube boiler without baffles. The cooling down of the gases is most rapid in the first row of tubes, slower in the second and so on since heat necessarily passes more and more slowly from gases to tubes as the temperature of the gases approaches that of the tubes. Finally, a row is reached where the amount of heat picked up is so small that this row barely "pays its keep." That is, the amount of heat recovered by this row is barely equal to the interest and depreciation charges on its cost (including that of the additional header length and setting height required). Each row beyond this is financially a loser. This consideration determines the economical height (in tube rows) of the boiler.

For a given boiler the flue temperature can be made to approach more closely to the steam temperature by keeping the tubes free from soot and scale which retard the flow of heat. Cutting down the excess air also reduces the flue temperature, so this produces a double saving.

Economizers and Air Heaters

While the last row of tubes in an economically designed boiler barely "pays its keep," further tubes can sometimes be added economically if they are filled with feed water at a lower temperature than the steam, thus increasing the temperature difference which determines the rate at which heat can be absorbed. Such tubes constitute an economizer; if part of the boiler construction, an "integral" economizer. While the tendency for some time, at least in this country, has been to build plants without economizers, the economizer is showing some signs of a new lease of life due to the increased cost of fuel and recently developed methods of preventing corrosion.

The desirability of installing an economizer is much affected by the design of the rest of the plant. If the feed water is fairly cold, the economizer can effect a considerable saving. If, on the other hand, it is already heated to a fairly high temperature by exhaust or bled steam, there is little left for the economizer to do. This opens a field for the air heater in which the flue gases heat the incoming air for combustion.

The proper division of feed heating between exhaust steam, bled steam, economizers and air heaters is a science in itself, involving the making of heat balances for the entire plant.

[1] The *percentage* of carbon dioxide in the flue gas can be changed, but the total weight of carbon dioxide produced by the complete combustion of a ton of a given coal is absolutely fixed.

New and Improved Equipment

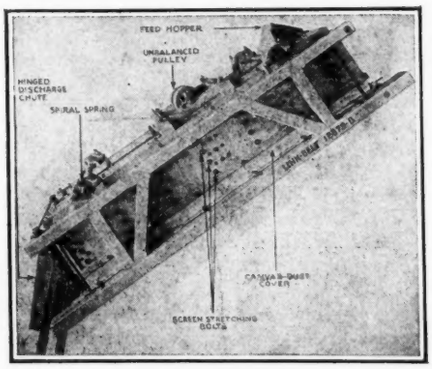


Fig. 1—Screen is mounted on spiral springs and vibrated by unbalanced pulley

Link-Belt Vibrating Screen

A vibrating screen designed to separate fine particles of coal, sand and other products, is a recent development of the Link-Belt Co., Philadelphia.

A feature of the machine is the provision made for vibrating the screen uniformly over the entire surface. This is accomplished by means of an unbalanced pulley which is supported on the screening frame and rotated at high speed.

The screen box, with feed hopper and discharge shut, is suspended from two hollow shafts the ends of which are carried on flat spiral springs on the supporting structure. The unbalanced pulley may be adjusted to impart to the screen box vibration of proper intensity and direction to screen different kinds of materials. The pulley is provided with a special bushing and is lubricated automatically under forced feed.

The screen box is arranged for one, two or three screen decks, depending upon whether two, three or four sizes of material are produced. The box is clamped to the stationary shaft carrying the vibrator pulley so that the vibrations are imparted directly to it.

The screen is arranged for belt drive and requires a comparatively small amount of power.

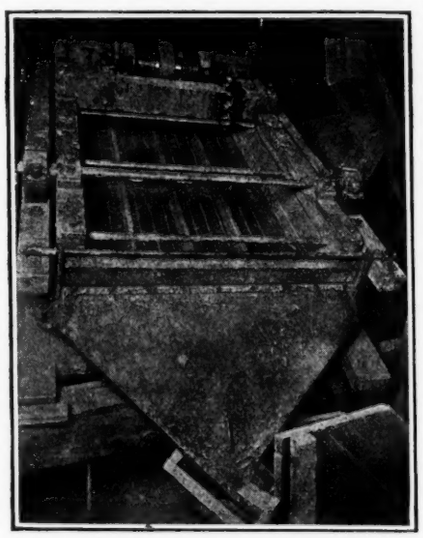


Fig. 2—Installation of vibrating screen

Skid Bars Replace Rollers on New Type Illinois Stoker

A recent improvement brought out by the Illinois Stoker Co. is the use of skid bars instead of rollers on their chain-grate stokers. In addition to the usual reduction in horsepower required to drive the chain and the reduction of parts liable to break, as in the case of the old roller construction, the makers claim that their new skid bar cuts sifting 90 per cent.

A redesign of the Type G stokers damper-controlled tuyeres also features the new machines. Cast iron with machined edges is now used in place of the sheet steel found in the older installations. This has brought about much better air distribution and control as well as lengthening the life of these parts. An improved feed-grate operating device with dustproof housing is now standard on the latest Type A stokers.

Trane Return Line Vacuum Pumps

A full line of vacuum pumps with receiver and full float and vacuum control for application to return lines has been developed recently by the Trane Company, of LaCrosse, Wis. A feature of the outfit is the use of independent air and water pumps. These pumps may be coupled to the same shaft and driven by a single motor or driven separately by individual motors, and frequently two such units of either arrangement are installed. For the duplex units the pumps of each are selected to carry about three-quarters of the full load, so that both are used for peak service, but for 90 per cent of the time one pump keeps water in the boiler and the proper vacuum on the return line, with the other in reserve.

Fig. 1 shows the two-motor return line special, as it is called. It will be seen that the condensation from the heating surface passes through a strainer and down into the receiver. Back of the strainer is the vacuum pump connection and between the two, the vacuum control switch. From the opposite end of the receiver the water pump has its suction, and as it is lower than the tank, it is always under head and requires no priming. It will be recognized that the automatic control shuts down the pump before the receiving tank is entirely drained.

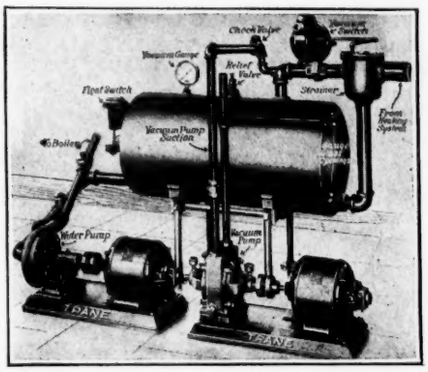


Fig. 1—Two-motor Trane return line special

Construction of the air pump is shown in Fig. 2. It consists of an impeller with vanes projecting laterally, which form buckets on either side so that the operation is symmetrical and there is no end thrust. Vapor drawn from the top of the receiving tank and condensed in the body of the air pump is the medium used to absorb the air. As the buckets approach the block-off point they are full of water, and, as they pass this point, they enter into a larger space having connection with the suction chamber. Owing to centrifugal action the water is hurled into the annular space and is broken up as it leaves the impeller by the action of the vanes. As a consequence the air is absorbed in the form of bubbles within the water as it passes the air gap at the top of the casing. In the concentric passage the air is carried around with the water for approximately one-half revolution and then rises to the inside of the buckets. As the outside passage begins to converge toward the center in the second half of the revolution, the air is driven from the water into the central chamber and from there to the outlet, an opening in the inner ring of the discharge plates on which the impeller revolves. The impeller has a

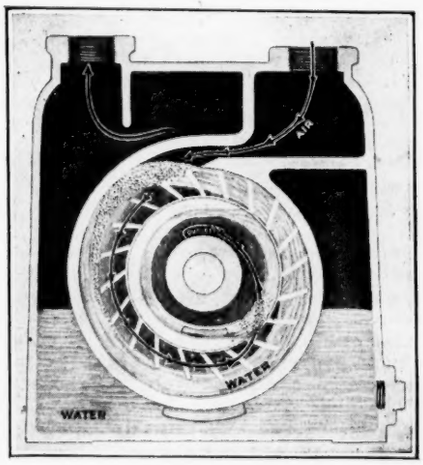


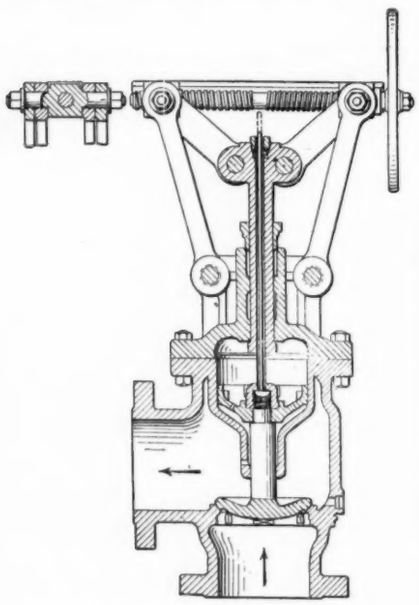
Fig. 2—Section through air pump

loose running fit at all points, and the shaft revolves in a chamber that is at atmospheric pressure, eliminating the need of tight stuffing boxes. The pump contains its own reservoir of water, so that it is self-priming and supplies its own needs indefinitely without a permanent source of supply.

The pump and receiver units are made in a variety of standard sizes and capacities ranging from 6,000 to 60,000 sq.ft. of direct radiation.

New Schutte & Koerting Non-Return Valves

The adoption of higher steam pressure in power plants, particularly in the larger central stations, has made necessary important changes in boilers,



Section of valve equipped with screw-and-toggle closing attachment

prime movers and other types of auxiliary equipment. To meet these demands, the Schutte & Koerting Co., Philadelphia, Pa., has developed a new line of non-return valves on which the usual straight stem is replaced by a screw-and-toggle attachment, as shown in the illustration. As the non-return valve is usually placed at or close to the boiler nozzles or superheater outlet, the customary practice of applying hydrostatic test of 50 per cent in excess of the normal working pressure subjects these valves to exceptionally high pressure, and frequently excessive strains are placed on the spindle in order to make the valve tight.

The closing attachment shown in the illustration consists of a right- and left-hand threaded horizontal screw spindle, having a handwheel at one end and two trunnion nuts to each of which are pivoted two long tension links pivoted at their lower ends to the valve cover, and also two short links pivoted at their lower end to a crosshead carried by the valve stem or spindle.

It will be seen that as the handwheel is rotated clockwise for closing, causing the trunnion nuts on the screw to approach each other, the leverage of the toggle linkage increases and reaches a maximum as the valve disk is forced to the seat.

Other features of the valve are the inserting of the closing cylinder and its piston between the body and the cover, also the employment of open seats without spider arms or hubs. The valves are made for 450 and 650 lb. working pressure, also for higher pressure as specified, and for temperatures up to 800 deg. F. They are also made in several different styles, including plain non-return, triple-duty and emergency-closing valves.

American Blower Unit Heater

The illustration, Fig. 1, shows a type of unit heater (Venturafin) recently developed by the American Blower Co., Detroit, Mich.

The heater consists essentially of a series of heating coils or tubes in a sheet-steel casing, on one side of which

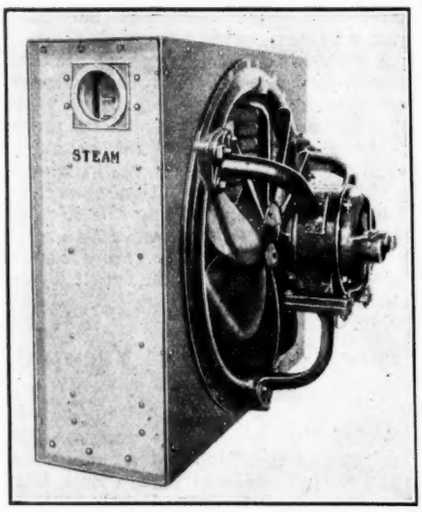


Fig. 1—Front view of heater

a motor-driven fan is mounted for forcing the air over the heated surfaces.

The steam coils are made from straight copper and brass tubing about which is helically wound a copper ribbon to form a continuous fin. By means of this fin the heat-transmitting surface is increased to nearly five times that of the tube alone. The tubes are arranged in rows usually three deep and staggered. The general details of construction are shown in Fig. 2.

The heaters are constructed for steam or liquid pressures up to 50 lb.

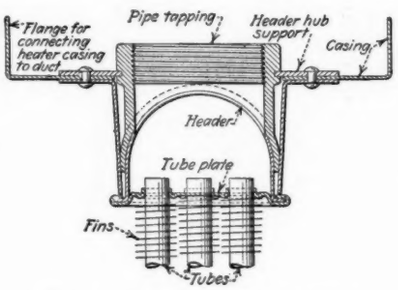


Fig. 2—Details of construction

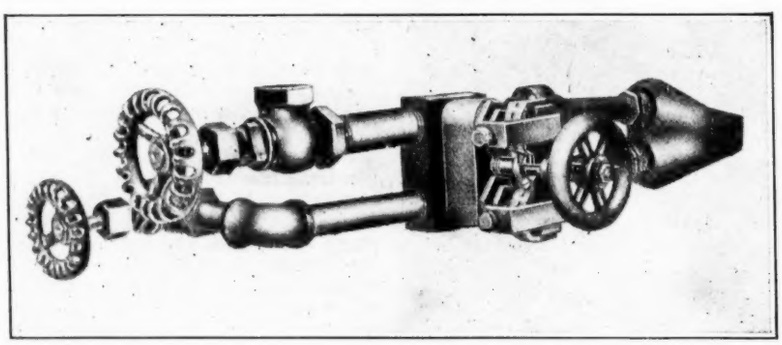
and any vacuum. They are made in sizes convenient for individual installation, or two, three or four heaters can be arranged to form one heating unit and in this way meet practically any installation requirement.

Foerst Twin-Con Valve for Fuel-Oil Burners

The illustration shows the Twin-Con valve recently developed by John Foerst & Sons, Bayonne, N. J.

The valve has been designed as a semi-automatic means for the control of fuel-oil burners on installations of the steam or compressed-air atomizing types and with a view to eliminating as far as possible the human element in the control of the mixture or proper atomization of the oil. This tends to obviate the soot caused from under-atomization and also the localized white heat destructive to tubes, shells, etc.

When the valve has been properly adjusted, the operation of one handwheel only is required to regulate the two elements for any range of load. It is claimed by the manufacturer that when the valve has been properly adjusted and locked in position, over or under atomization of the fuel cannot occur, also that the only important requirement necessary for the proper functioning of the valve is a constant oil pressure with fluctuations not exceeding five pounds.



Operation of one handwheel automatically regulates atomization over a wide range

The Cause and Control of Corrosion in Heating Systems

ALTHOUGH the investigation by the Committee on Corrosion of the National District Heating Association reported at the New York convention June 10-12, has not yet been completed, it is pointed out that some tentative conclusions may be drawn, as a result of the work so far done by its members, J. C. Hobbs, F. N. Speller and J. H. Walker, chairman. Oxygen in water or steam is an important corrosion factor, which perhaps dominates in central heating work and should be kept below the danger point. Heating systems in many instances add oxygen to the steam or water supplied, with corrosive action as a result, so that the treatment of the water in a central heating plant for removal of oxygen does not necessarily prevent this in the consumer's system.

Both the exterior and interior corrosion of underground pipes are considered. The former is briefly discussed, the reader being referred to the reports of the Bureau of Standards and the Committee on Electrolysis, 1921, American Institute of Electrical Engineers.

Intelligent treatment of boiler-feed water to render it and the steam generated non-corrosive is the most effective means of protection against internal corrosion frequent in central heating systems.

Free oxygen does not rust pipes directly, but is simply an aid in causing iron to be dissolved, and the formation of ferric and ferrous oxide, according to a paper by F. N. Speller, read at the annual meeting of the American Society of Heating and Ventilating Engineers in January, 1918, entitled "The Preservation of Hot Water Supply Pipe in Theory and Practice." The mechanism of this reaction is indicated in the figure.

Water containing a small amount of dissolved oxygen is shown at *A*. The water tends to break up into a positive hydrogen ion H, and a negative hydroxyl ion, OH as indicated. There is also an extremely minute proportion of the water already dissociated in this form, but the largest part of the water is not dissociated.

When iron is introduced into the system as at *B*, some parts of the surface contain higher electric charges than others such as where there are pieces of mill scale as shown at the left. These contain positive charges and represent the anode, while other parts show a less potential, which, therefore, amounts to a negative, or cathode, as at the right. The positive hydrogen ions are attracted to the negative, or cathode, while the negative hydroxyl ions naturally approach the positive, or anode. A current of electricity tends to run through the solution from the anode to the cathode.

The result is that iron ions combine at the anode with the hydroxyl ions, forming $Fe(OH)_2$. More water becomes dissociated, so that a greater amount of the hydroxide is formed, with an increasing amount of hydrogen collecting on the negative areas. This tends to insulate against the current, which, if stopped, will prevent the iron from being given up.

The free oxygen, as at *C*, combines with this hydrogen, allowing the electrolytic action to continue and also oxidizes some of the $Fe(OH)_2$ to $Fe(OH)_3$, or $4\,Fe(OH)_2 + O_2 + 2H_2O = 4\,Fe(OH)_3$. After the free oxygen is used up, bubbles of hydrogen continue to cover the cathode area finally preventing the circulation of electric current, and therefore stopping corrosion, as indicated at *D*.

The presence of dissolved oxygen in no sense causes corrosion, but merely aids in its unimpeded operation, whether the water is pure or slightly acid. If a salt be present in the water, the metallic element of which is deposited or plated on the cathode surface by the current, it is evident that the electric charge of the metal deposited will raise or lower the discharge potential and therefore determine whether electrolysis should be less or greater, and eventually determine whether corrosion will cease or become more active. Arsenic compounds are well known as preventive mediums, as arsenic deposited over cathodic spots tends to insulate against the electric current.

Corrosion is usually characterized by the liberation of hydrogen and the formation of the iron hydroxides, $Fe(OH)_2$ and $Fe(OH)_3$, ordinarily called rust. These are quite insoluble and may be turned into iron oxide by the application of heat.

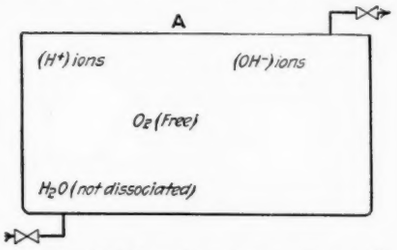
There is no positive proof that this action can be promoted by carbon dioxide or by any other similar gas if oxygen is not present. It is true that carbon dioxide causes acidity and implies a greater tendency toward corrosion. Oxygen, however, is the usual depolarizer, which combines with the hydrogen, thus allowing the action to continue, and therefore is regarded as the key of the situation.

In boiler plants oxygen may be eliminated by deaëration, accomplished either mechanically, such as by boiling at a low vacuum, or by deactivation, in which the oxygen is removed from the water through the agency of a material causing fixation of the free oxygen present.

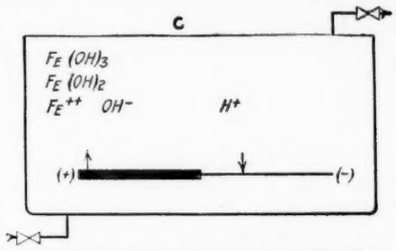
Corrosion in the heating system is more difficult to control than that in the boiler plant. Oxygen frequently finds its way into heating systems, thus producing corrosive water or steam in spite of the fact that the fluid had been supplied in a non-corrosive condition. Tests conducted on a heating system where considerable trouble of this kind was noticed, indicated that the steam entering was practically in a non-corrosive condition, but acquired this property due to the oxygen picked up in the system, from contact with air.

Tests on a vacuum system indicated that that discharge contained four times as great an amount of dissolved oxygen as that in the entering steam. When the same system was operated as a pressure system, the returns showed ten times as much as in the supply. Findings in general were somewhat contradictory, as to conclusions to be drawn regarding the type of system and its bearing on corrosion.

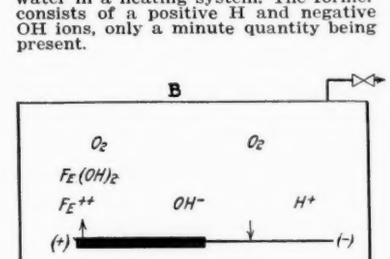
Where there is more or less air in return lines, or where air enters as in a vacuum system, conditions are favorable for the addition of oxygen. A one- or two-pipe system, however, without radiator traps, shows little inclination to increase corrosiveness.



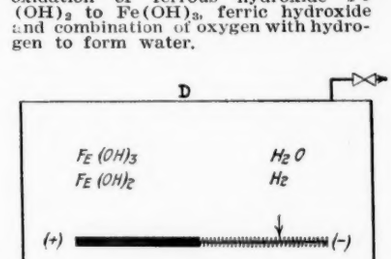
Dissociated water, free oxygen and water in a heating system. The former consists of a positive H and negative OH ions, only a minute quantity being present.



Second stage of corrosion is the oxidation of ferrous hydroxide Fe $(OH)_2$ to $Fe(OH)_3$, ferric hydroxide and combination of oxygen with hydrogen to form water.



Positive or anode area caused by mill scale produces an electric current. Negative OH is attracted to the positive areas giving $Fe(OH)_2$, and positive H to the cathodes.



When oxygen is exhausted further supply of hydrogen gas accumulates on the cathode and insulates against the electric current so that corrosion ceases.

Corrosion stops after free oxygen unites with hydrogen

State Versus Private Management of Power Plants*

By Dr. Arthur Twining Hadley†

UNTIL recent years there was little call for state ownership of power plants as a measure of national policy. But in the present century two causes have combined to foster a sentiment in favor of making electric-power production a government enterprise.

In the first place the increased use of water as a source of power, in itself fostered such a demand. Private companies that used water appeared to many people to be getting their power at public expense because the government had given them control of a natural monopoly. The general public did not understand how much capital and intelligence were needed to make water power available for use. And in the second place, it has gradually become evident that the different power plants of the country could no longer be regarded as wholly separate operating units. They must work together as an organized nation-wide system, if they are to deliver and sell their product to the best advantage. Any government is always inclined to be jealous of a nation-wide organization which it does not itself make and control. And this jealousy has been heightened by the name chosen for the new movement. The word "superpower" is not calculated to allay outside prejudice; nor was the proposed substitute, "giant power" much better. Either term suggests an intent to dominate the industry of the country rather than to promote mutual helpfulness.

Under such circumstances the question of public versus private management tends to become one of sentiment rather than of business. Even if you can show a large number of instances where state management costs more than private management, or has involved higher rates, or has been given up by communities that have tried it, you do not make much impression on the advocates of government ownership. "The new democracy is passionately benevolent and passionately fond of power."

Industries of Two Kinds

Industries are of two kinds—the standardized and the progressive. In the standardized type, of which the post office, the telegraph and the municipal water supply are examples, a large part of the work is a matter of routine. Honest administration and faithful performance of service are the all-important conditions. The capital invested is either small in proportion to the year's business, as in the post office, or subject to easily calculated depreciation charges, as in the water supply. The necessity rarely arises for making radical changes of method to keep abreast of the times or scrapping plant before it is worn out because new inventions have rendered it obsolete. The year's budget can therefore reflect the year's operations pretty accurately and show whether there is a real profit or a loss concealed under the appearance of a profit.

In the progressive industries all these conditions are reversed. The success of the work depends upon something more than the performance of routine duties. The amount of capital involved is large. Depreciation cannot be accurately calculated. New inventions and new methods often render plant obsolete before it is worn out. The year's budget does not and cannot accurately reflect the year's conditions.

The history of state-owned industries in the Nineteenth Century shows that government does relatively well with standardized industries like the post office, and relatively ill with progressive ones like the railroad.

Electric-Power Industry Progressive

Among the large industries of the present day the one that is least standardized and most progressive in its character is the electric-power industry. Among those of the Nineteenth Century the one which was least standardized and most progressive was the railroad industry. Amid all their external differences the things that affect the relations of these two industries to the government are singularly alike. The history of state railroad management in the last century should therefore indicate with a good deal of accuracy what results we may expect to reach and what dangers we have to fear if electric-power development should be placed in government hands.

In the first place, state railroads have habitually proved unprofitable. Though every great country with the exception of Great Britain has made experiments in state railroad operation, only two, Prussia and the South African Dominion, have succeeded in earning the full amount of interest on the capital invested. Some others, like Sweden or New South Wales, have pretty nearly succeeded in doing it; but, in general, state railroads have constituted a large and increasing burden on the taxpayers.

In the second place, no operating improvement of importance has ever had its origin on a government railroad system. Telegraphic train orders, interlocking switches and signals, air brakes, automatic couplers, all had their origin on the private railroads of England or America.

In the third place, the state roads were equally backward in commercial improvement. The thing that made it practicable to reduce railroad rates so rapidly during the latter half of the Nineteenth Century was the development of a system of tariffs which made a large traffic in cheap goods possible, which encouraged long-distance shipments, and which utilized the invested capital to the fullest extent.

How do the advocates of state ownership of power plants try to rebut the presumption created by these facts? The answer generally is that they propose to give lower rates to the consumer either now or in the future than private companies can afford to give. They claim that they are able to do this by their exemption from taxation and by the fact that they are not trying to make a profit as private companies do, but are content to pay interest and perhaps contribute to a sinking fund. Looking at the question as a matter of economic theory, both these methods of lowering costs are wrong in principle—harmful rather than helpful to the community and particularly harmful under conditions as they exist at present.

The second method by which it is proposed to reduce costs of government enterprise is by foregoing profits. In the light of the history of railroads in the previous century, it would perhaps be sufficient to say that this offers no prospects at all. Let us assume that Twentieth Century governments know more about managing industry than Nineteenth Century governments; that they could make a profit if they tried, but that they deliberately decide to operate at cost. I hold that in the case of a progressive industry as distinct from a standardized one, this attempt is unsound in principle and will hurt the public instead of helping it.

How Profits Are Made

In an industry where rates are kept at a reasonable figure, either by competition or by the action of public service commissions, profits are made in two ways—by developing new business that allows the plant to be better utilized, or by introducing new machines or methods that cheapen the direct cost per unit of traffic. In the first there is an immediate public gain in the form of larger service; in the second there is a possibility of public gain which becomes an actuality as soon as the use of the new method becomes general. For the experience of every industry with large fixed capital shows that a reduction of unit costs makes a reduction of rates not only possible but profitable. This is the way progress is made.

Government in Power Business

As the electric industries constitute a field where there is exceptional room for progress in the immediate future, both on the operating and on the commercial side, it seems most undesirable that electric power generation should become a government monopoly at the present juncture. If a particular group of municipalities believes that it can get its light and power cheaper by organizing a co-operative agency, let it do so; or if the government thinks that it can develop some of the nation's water power to better advantage than private companies, let it do so. But let it go into the competition on equal terms with private companies as to taxation and regulation. In this way and in this way only can it prove whether it is really cheaper and better for the community. The history of state management of progressive industries in the last hundred years creates a strong presumption against the encouragement of government-owned electric plants by special privileges.

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*Abstract from a paper presented at the First World Power Conference, held at the British Empire Exposition, Wembly, London, England, June 30 to July 12, 1924.

†President Emeritus, Yale University, New Haven, Conn.

Air Mail Service Will Be Welcomed

The transcontinental air mail service is going to be appreciated by industry generally, and it will be of especial service to publishers of trade and industrial periodicals in expediting special letters and last minute copy from correspondents. Reports and late news can be sent complete by this service, where formerly they were of necessity abridged on account of the expense of the telegraph. It will also be of especial service to bidders on equipment, as a saving of from one to two days can be made.

The post office has arranged a summer schedule so that mail leaving New York City will arrive in San Francisco in 32 hours and 5 minutes. The rates for the service will be 8 cents an ounce or fraction for each zone or part of zone in which the mail is carried. So far three zones have been established; New York to Chicago, Chicago to Cheyenne, Wyo., and Cheyenne to San Francisco.

Tornado Blows Over Stack at Lorain, Ohio

The tornado that wrought such great destruction of life and property at Lorain, Ohio, on June 28, did not leave the electric light and power industry unscathed. Lines went down in many directions, and at Lorain a brick smokestack of the local plant and a substation structure were demolished. The damage to the Edgewater power station, the main generating plant of the Ohio Public Service Co., according to information furnished by J. B. Johnson, manager of the Lorain division, was mainly the destruction of one 275-ft. brick stack with some injury to the building caused by the falling stack material. No damage was done to any of the generating equipment, boilers or switchboard. A steel-framework substation, recently erected, was blown down but without damage to transformers or oil-circuit breakers other than the destruction of insulators. The transmissions lines were all destroyed through the storm area, and one steel tower was destroyed.

The distribution system and street lighting system, covering an area approximately one-half mile wide and one and one-half miles long, was almost completely destroyed.

The storm, which also swept through central Illinois and Iowa, did most damage to the properties of the Illinois Power & Light Corp. in Des Moines, Iowa, where poles were blown down and trees uprooted and blown across power lines throwing the city in darkness. At Peoria and also at Galesburg, Ill., damage was done to the properties of the Illinois traction system. Restoration of service was speedy, emergency service being restored in hospitals and other essential points on Sunday morning.

60,000-Kw. Single Unit Turbo-Generators

The first two units for the new 700,000-kw. station to be constructed by the New York Edison Co., have been ordered. These will be single-unit G. E. machines of 60,000 kw. capacity unity power factor, 25 cycles, 11,400 volts, three-phase and will run at 1,500 r.p.m. The operating conditions will be 350 lb. pressure and 700 deg. Each will be equipped with a direct-connected exciter and will exceed by 10,000 kw. the present largest unit of this type.

Birmingham (Eng.) To Use Pulverized Coal

The City of Birmingham, England, has recently placed an order for the installation of pulverized-fuel equipment in its Nechells power station. The equipment will consist of six Vickers-Spearing boilers, each having 5,400 sq.ft. of heating surface and equipped with a Lopulco type combustion chambers fitted with patent water screen; four gravity waste-heat type driers; four Raymond 6-roll pulverizers; six groups of Lopulco feeders; and twenty-four Lopulco burners. The contract has been placed with the Vickers & International Combustion Engineering, Ltd., London.

Pennsylvania Orders Inquiry Into Electric Service

The Public Service Commission of the Commonwealth of Pennsylvania has ordered an inquiry with hearings to begin on July 9 in the offices of the Commission in Harrisburg, Pa., to establish, by rules and regulations, reasonable and proper standards for rural electric service and facilities, as affecting the safety and accommodation and convenience of the public and also that such electric service be extended to rural residents of the commonwealth who may wish the service, upon a reasonable and non-discriminatory basis. The investigation is to be held under the rules of the Public Service Company Law and the order directs that such investigation and inquiry shall deal broadly with all pertinent and relevant matters with the view that by appropriate order or orders thereafter to be made, the fullest practicable simplification and standardization of rural electric facilities and service reasonably necessary for the public shall be secured for them.

Seward Plant To Be Enlarged

The Penn Public Service Corp. has recently authorized an extension to its Seward plant, which was built in 1920. The extension will consist of two new boilers equipped with preheaters and fans, one new stack and new boiler-feed pumps. The stoker equipment will be the exact duplicate of that already installed. Dwight P. Robinson & Co., Inc., designers and builders of the Seward plant have been given the order for the extension.

Reorganization of Federal Bureaus Intricate Affair

Correspondence reaching Washington indicates a misapprehension on the part of the mineral industries as to the status of the reorganization legislation. The proposed plan, which would transfer the statistics of mineral production from the Geological Survey to an enlarged Bureau of the Census, to be known as the Bureau of Statistics, is far from an accomplished fact. The whole question of reorganizing the government departments is so intricate and controverted that it is entirely possible that no legislation along the lines indicated in the Mapes bill will pass. Before any such plan is made effective, it is safe to predict that it will have been amended in a great many particulars. The prospects are that the proposal with regard to the mineral statistics will not be approved, since it is opposed in the Bureau of the Census as well as in the Geological Survey.

It is evident that the anxiety of the mineral industries concerned with statistical service is due to the reliance that must be placed on these figures, as long as the status of trade associations remains in doubt. Many of these organizations have abandoned a portion of their statistical program, pending the clarification of their legality. For that reason such statistics as are issued by the government, assume an increased importance.

The Bureau of the Census and the Geological Survey are typical of two distinct methods of approaching the statistical task. The Census Bureau deals with a wide range of subjects, in addition to the task of enumerating the population. As Secretary Hoover puts it, the Bureau dredges up great buckets of facts.

The Geological Survey, on the other hand, produces a type of statistics in which the statistical results are regarded not as an end in themselves but as a means to a larger end—which is an understanding of the industry. The secret of their merit is the vital contact between the collection of the

data and their application to the industry.

Industry is not interested in the department or in the bureau that handles its statistics. It is generally recognized by industry, however, that the work should be done by those who make it their permanent job to study some particular specialty. Thus the coal statistics are handled by coal specialists, the oil figures by petroleum specialists, rare metals figures by men who devote their entire time to that specialty, and so on through the list.

Increase in Bituminous Coal Exports

According to government reports, exports of bituminous coal from the United States during May, amounting to 1,231,740 long tons, show a decided increase as compared with the 942,638 tons shipped in April and, with the exception of exports during February, were the largest monthly exports during the present year.

Overseas shipments (excluding tonnage to Canada, Newfoundland and Labrador) however, amounted to only 312,417 tons, being less than the exports overseas during April. This decrease is offset by heavier exports to Canada, 910,563 tons being sent to that country in May, against 542,358 in the preceding month.

Three European countries received bituminous coal from the United States during May, there being a decided drop in shipments to both France and Italy, 28,949 tons going to the former country in May as compared with 78,551 tons in April; while only 51,962 tons were destined for Italy against 109,433 tons in the preceding month. Greece enters into this trade for the second month of this year, with 1,000 tons.

The South American trade showed a considerable increase during May, to 170,224 from 107,471 tons in April. A great part of this increase is due to large shipments to Brazil, Chile and Peru. In some cases, particularly Chile, Peru, Uruguay and Brazil, exports during the first five months of 1924 have already surpassed the total amount shipped during the year 1923. Of particular interest in this South American trade have been the heavy exports of bituminous coal during the last few months to Brazil, reaching 122,059 tons in May, against 73,508 tons in April.

Additions to Shanghai Power Plant Planned

Enlargement of its present electric power plant to a capacity of 10,000 kw. is being contemplated by the French Tramway & Electric Light Co. of Shanghai, China, according to government reports. About half of the proposed increase is to be put in during 1924 and the remainder during 1925.

Electricity Project in Western Australia

Favorable consideration has been given to a plan for the establishment of a power station at the mouth of the Collie coal mines in Western Australia. This project involves the distribution of electric power in a manner similar to the Morwell electricity scheme in the State of Victoria, Australia, according to *Commerce Reports.*

50,000-Kw. Cross-Compound Turbine for Hell Gate

A contract has been recently awarded by the United Electric Light & Power Co. for a 50,000-kw. cross-compound turbine-generator unit which will consist of a high- and low-pressure turbine, two main generators of 25,000 kw. each, and an auxiliary 2,000-kw. generator directly connected to one of the main generators. The field current will be supplied to the two main generators by a large direct-connected exciter, while a small exciter will serve the auxiliary generator. The unit will be installed at the company's Hell Gate station, and is made necessary by the increasing load for general light and power purposes in the Metropolitan district. This equipment is a duplicate of a previous order from the same company, which is now in the process of manufacture.

Caracas To Have Two New Power Plants

Two syndicates have been formed to undertake the construction of electric power plants to furnish light and power to the City of Caracas, Venezuela, according to *Commerce Reports.* It is proposed to build a hydro-electric plant on the Carisco River, while a second plant, using crude-oil engines of 2,000 hp., will be erected in Caracas.

St. Lawrence Commission Will Report This Fall

No further development from the United States St. Lawrence Commission, named by President Coolidge to co-operate with a Canadian commission in revised studies of the cost and feasibility of navigation and hydro-electric work on the St. Lawrence River, may be expected until fall.

Secretary of Commerce Hoover, who is chairman of this commission, expressed satisfaction with the results of the recent tour of the St. Lawrence, made by members of the American Commission, on his return to Washington. He stated that the tour had afforded the Commissioners an excellent opportunity to visualize the problems and that the members of the engineering board, General Jadwin and Colonel Kelly, had had opportunity to confer for eight days with members of the Canadian engineering board. The engineering advisers also have returned to Washington and will prepare their report on preliminary engineering data as soon as possible. Meanwhile a staff in the Department of Commerce is preparing economic data bearing on the situation. Until these data are received by the Commission, it is not believed that any further step will be taken. The two reports may be expected some time in September or early in October.

Speaking of the proposed developments in general, Secretary Hoover said that the entire matter is in an undeveloped stage and that what may be done remains for the future to decide.

Sargent & Lundy Employees Hold Their Second Annual Banquet. One Hundred and Seventy of the 257 Employees Were in Attendance to Wish Their President, W. S. Monroe, a Bon Voyage to the International Power Conference at London

Coal Storage Report of American Engineering Council Made Public

Advocates Uniform Monthly Deliveries—Storage at Point of Use—Gives Figures on Cost of Storage—Says Cars Should Be Assigned Upon Basis of Coal Sold

DANGER of coal famine will be eliminated, industry stabilized, railroads relieved and the consumer's coal bill ultimately cut by seasonal storage of coal, it is asserted in the 110,000 word report of the Storage Coal Committee of the American Engineering Council made public on July 7.

"The storage of coal," the report declares, "is essentially necessary as an aid to the solution of the national coal problem, and is an economic and practicable means of insuring an adequate supply of coal as needed.

"If each coal consumer will adopt the policy of annually purchasing coal on a uniform monthly delivery basis, there will result automatically sufficient seasonal storage to guarantee coal to the consumer, as needed. Furthermore, this policy will bring about a uniform demand for coal whereby the coal producer and carrier may establish uniform and standard production and shipment schedules.

"It will also remove the evils of intermittent operation of coal mines, frequent panicky market conditions, and coal shortages due to inability of the carriers to meet peak demands.

"The irregularity in coal production is largely due to seasonal demand. Since more coal is consumed in the late fall and winter than at other periods, coal producers and carriers each year are confronted alternately with a feast and a famine—with an inordinate demand for coal and transportation followed by a period of no demand. This seasonal demand is responsible for 47 per cent of the idle time of the coal industry.

"Seasonal demand also contributes to another very disturbing element, namely, the over-development of mine capacity through the opening of too many mines. Coal production capacity is now twice as large as the consumption capacity. The two factors—intermittent or seasonal operation and over-development—are in a very large measure responsible for the ills of the coal industry.

"The amount of storage required to produce these corrective and constructive results is small in terms of the per cent of annual consumption. For seasonal storage, from 9 to 10 per cent of the annual consumption is all that is required. If this amount is supplemented by additional reserve storage of no more than 7 per cent, there will result an accumulation of some 83,000,000 tons of coal in storage by September 30 of each year. The practicability of this amount of storage with but slight additional outlay for equipment is indicated by the fact that in September, 1923, 56,000,000 tons were in storage.

"Equipment has been developed and may be secured to meet any storage situation or requirement. The cost of such equipment ranges from a few cents per ton of capacity up to $3.

"Storage of coal presents no serious risk of loss from breakage, spontaneous combustion, or loss of heat value or firing qualities. All kinds of coal have been and may be successfully stored. The insignificant money loss due to the factors named above should not deter anyone from storing coal. Application of the simple and inexpensive regulations and practices set forth in this report will provide all reasonable safeguards against such possible losses.

"The cost of storage per ton, including fixed charges on equipment, maintenance and operation expense and interest on investment in coal as well as taxes and insurance, in most instances does not exceed seventy-five cents per ton yearly. More generally it is around fifty cents per ton yearly. This cost is insignificant when distributed over annual consumption.

"Storing of coal may be easily financed. Banks will finance such an investment as readily as any other commercial undertaking.

"The transportation facilities of the United States are adequately normal for regular movement of coal. For short periods the railways can move coal at an abnormal rate, but this is both expensive and detrimental to shipment of other commodities and to normal freight movement.

"To increase transportation facilities to meet the peak demands resulting from the prevailing unsystematic practice in coal shipment would require an additional investment of some $12,000,000,000. Such an investment is not justified.

"The railroads have more to gain by storing coal than any other class of consumer. They should store their own coal on such a scale and at such times as to obviate the movement of company or non-revenue producing coal during the period when there is a heavy demand for the transportation of revenue producing freight. They should abandon, however, the uneconomic practice of using freight cars for storing coal and thereby withholding railroad equipment from other uses.

"In general, storage should take place at the point of use, to accomplish the most in relieving transportation and safeguarding supply. However, under some circumstances, storage-in-transit or at an intermediate point is advisable.

"In general, storage at mines is not recommended, but there should be sufficient mine storage facilities and capacity to overcome ordinary operating delays, such as belated arrival of cars, temporary break down or idleness of mining equipment and the like. Such provisions would materially increase the producing hours of mines and miners.

"Cars should be assigned to mines upon the basis of coal actually sold and not upon rated capacity of production. This measure would be a wholesome deterrent to over-development of coal producing facilities.

"While this study refers primarily to industrial consumers of bituminous coal, yet householders have also a direct responsibility. Indeed the householder is in a position to aid with the least cost, because no special equipment for storing and reclaiming is required and his individual investment in coal is relatively small. Householders use approximately 50,000,000 tons of bituminous coal annually, which, if placed in their bins by the end of September of each year would materially contribute to the solution of the coal problem.

"Federal, state, city and other civic divisions of the body politic are not meeting their responsibility in relation to the seasonal storage of coal. They are as derelict in regard to seasonal storage as are other users and frequently add to a confused situation by securing priority orders. Public officials should take the lead, by precept and by example, in furthering the storage of coal.

"Contracts for coal should be observed with fidelity. The evil practice of indiscriminate breaking of coal contracts has seriously injured the American coal industry with reference alike to production, transportation and consumption. Contracts for coal should be observed with the same good faith as universally prevails in regard to other forms of commercial contracts.

"Confirmation of the practicability of coal storage is afforded by the anthracite coal industry. This industry is far more stable than the bituminous, because producers, carriers and consumers of anthracite coal for a number of years have practiced storage."

The committee recommends that all coal consumers purchase their coal on an annual contract for yearly requirements with a provision that the coal be delivered monthly in equal allotments.

"These recommendations," the report points out, "are based upon the finding that the purchase of coal upon a uniform monthly delivery basis will result in a condition whereby coal mines may inaugurate and maintain a regular production schedule; carriers may plan definitely as regards both schedules and equipment for a uniform movement of coal; stocks of coal automatically will accumulate during the months from April to September, inclusive, in sufficient amount to meet the extra consumption during the winter months; a reduction in the price of coal will be made possible by more regular schedules of production and transportation and by elimination of peak demands in the winter months when the costs of both production and transportation are the highest."

The United States exported to Sweden during the years 1922-23: power-generating machinery, except electric, amounting to $23,626 in 1922 and $34,082 in 1923; construction and conveying machinery, $27,847 in 1922 and $13,782 in 1923; mining, oil-well and pumping machinery, $51,729 in 1922 and $19,407 in 1923.

Diesel Electric Tugboat Tested

The Pennsylvania Railroad System announced on July 2 that the Diesel electric "Tugboat No. 16" is now receiving its dock and river trials in the Upper Bay and Hudson River. The tug is not only propelled by electricity, but the pilot directly controls the propelling apparatus. Instead of transmitting signals to the engine room calling for "full speed ahead," etc., he manipulates the propelling motor by levers in the manner that a motorman controls an electric car. The boat is 24 ft. long and draws 12 ft. of water.

Railroads Buy 28 per Cent of Soft Coal

According to the statement of R. H. Aishton, president of the American Railway Association, the railroads in 1923 expended $617,800,000 for fuel, which was about one-third of their total expenditures. More than 28 per cent of the bituminous coal produced in the United States in 1923 was purchased by the railroads at a cost of $519,007,000, while they purchased 5.2 per cent of the total anthracite production at a cost of $18,195,000. Fuel oil amounting to $75,867,000 and consisting of about one-fifth of the total production and consumption in the United States, was also purchased by the railroads, while $4,731,000 was expended for other kinds of fuel such as coke and gasoline. These amounts represent expenditures on account of fuel for all purposes, whether for locomotive, shops or the heating of buildings.

Personal Mention

Charles F. Lindsay announces his association with Perin & Marshall, specialists in power and steam surveys and reports, waste-heat utilization, industrial investigations, design and construction, etc. The offices are at 40 West 40th St., New York City.

John H. Dunlap, secretary of the A.S.C.E., was injured in a wreck of a fast mail train at Buda, Ill., on June 30, when returning from the convention of the Society for the Promotion of Engineering Education held at Boulder, Colo. Mr. Dunlap was injured about the spine and was taken to the Presbyterian Hospital in Chicago, where an X-ray examination showed that his spine had not been fractured.

Business Notes

Purifier, Steam—Andrews Bradshaw Co., Pittsburgh, Pa. Catalog, "Tracy Steam Purifier" tells what this purifier will do and gives illustrations of installations and applications.

The Industrial Works, Bay City, Mich., announces the appointments of Max Riebenack, 3rd, of Lansdowne, Pa., as district sales engineer stationed at Philadelphia; and Ben W. Beyer, Jr., as district sales manager at the New York City office.

The McClave-Brooks Co., Scranton, Pa., announces changes in sales offices and personnel: G. Marshall Everson has been appointed district sales manager of the Pittsburgh district with offices in the Oliver Bldg., Pittsburgh, Pa.; a new branch office has been opened at Indianapolis, Ind., at 718 East 27th St., which will be in charge of Harlan W. Bird; the appointment of the Adkins, Young & Allen Co. of Chicago as representative for the southern section of Wisconsin.

Coming Conventions

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Sept. 25-27.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute of Brooklyn, New York. Summer meeting in Denver, July 16-19.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Fall convention at Pasadena, Calif., Oct. 13-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn meeting at Birmingham, Ala., Oct. 13-15.

American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Fall meeting at Detroit Oct. 23-25.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

International Union of Steam and Operating Engineers. Dave Evans, 6334 Yale Ave., Chicago, Ill. Biennial convention at Detroit, Mich., Sept. 8-13.

Management Congress, First International. Prague, Czechoslovak, July 21-24.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Wisconsin Association** at Fond du Lac, July 24-26. Vincent Todd, 25 Fourteenth St., Fond du Lac. **Minnesota Association** at Faribault, Minn., July 31, Aug. 1-2. C. A. Nelson, 800 22nd Ave., N. E. Minneapolis. **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids. **Pennsylvania State Association** at Grand Rapids, Mich., Sept. 8. J. N. Calvert, Union & Ridenour Ave., Crafton, Pittsburgh, Pa.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Ohio Electric Light Association. D. L. Gaskill, Greenville, Ohio. Annual meeting at Hotel Breakers, Cedar Point, Ohio, July 8-11.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

The Sanford Riley Stoker Co., Worcester, Mass., announces that C. O. Hoban, formerly of the sales staff of that organization, has been appointed company representative for western Pennsylvania and West Virginia, with headquarters at 1216 Farmers Bank Bldg., Pittsburgh, Pa.

The Arrowhead Iron Works, Inc., has recently been organized and incorporated under the laws of Missouri for the manufacture of Arrowhead steel gratings, steel treads and fire-escape steps on a large scale. The officers and directors are: president, William L. Pattison; first vice-president, Walter B. Richards; second vice-president, John A. Conover; treasurer, Joseph E. Woodmansee; secretary, Stewart H. Richards. The home office will be located at 200 West Fifth St., Kansas City, Mo., and licensee offices will be maintained in New York, Chicago and San Francisco. Fabrication factories are also contemplated at these cities.

Trade Catalogs

Diesel Engines—**The Fulton** Iron Works Co., St. Louis, Mo. Bulletin No. 806, "The Fulton-Diesel in Industry," pictures the Fulton-Diesel engines installed in a cement plant, an iron mine, an ice plant, flour mill, sugar mill and clay products plant.

Boilers — The Page Water-Tube Boiler Co., 815-819 Larrabee St., Chicago, Ill., has just published a twelve-page illustrated catalog describing the Page Cross-Drum Water-Tube boiler. Several pages of the booklet are devoted to drawings showing the boiler settings.

Regulators, Boiler-Feed Water—The A. C. Neilson Co., Chicago, Ill., have made a close investigation of the cost of operating Copes regulators in the Warner Sugar Refining Co., Edgewater, N. J. This report gives a summation of the savings effected by the use of these regulators. A copy of the report may be obtained from the Northern Equipment Co., Erie, Pa., manufacturer of this equipment.

Conveying Machinery—Catalogs are requested from manufacturers of elevators and conveyors for use in connection with the promotion of trade in India, and for use by the Indian Stores Department in making purchases of conveying machinery. Catalogs should be forwarded, in triplicate, to "Mr. James E. Miller, Trade Commissioner, Room 29, Grosvenor House, 21 Old Court House St., Calcutta, India."

Pyrometers, Superheated Steam—The Superheater Company of New York and Chicago has just issued a second addition to its Instruction Book covering installation, operation and maintenance for Model 496 Superheated Steam Pyrometers. In addition to instructions covering the application of the pyrometer to superheater locomotives there are also given special instructions relating to marine and industrial plants. A pyrometer test set is described and inspection of the pyrometer and tests of various parts with and without the test set are given.

Refractories—Quigley Furnace Specialties Co., Inc., 26 Cortlandt St., New York City. "Hytempite in the Power Plant" is the name of a catalog recently published which shows the benefits of this refractory. Illustrations of installations and methods of use as well as tables and instruction are included.

Insulation Testing—James G. Biddle, Scientific Instruments, 1211-1213 Arch St., Philadelphia. Pocket Manual 1060 "Concerning Insulation Testing with Special Reference to the Meg," contains up-to-date data on the insulation of electrical appratus, causes of breakdown, effects of moisture, surface leaks, temperature, etc. It describes "Meg" and "super-Meg" insulation testers and gives full information for making tests with "Meg" on various types of electrical apparatus. It is well illustrated with charts and photographs. Its convenient size makes it a useful booklet to have.

Oil Purifiers and Burners—A firm in Manila has requested catalogs and prices on oil purifiers of 5 to 10 gal. per hr. capacity and on separators of 8 to 35 gal. per hr. capacity. Complete information is wanted, including blueprints showing the method of installation, cuts or drawings, shipping weights properly boxed for export shipment, code words for placing orders, c.i.f. Manila prices on oil burners for 80, 100, 150 and 260 horsepower installations. B. & W. boilers with two 28-inch flues each are to be used. American manufacturers may forward printed matter to Assistant Trade Commissioner C. P. Goodhue, 510-512 Masonic Bldg., Manila, Philippine Islands.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	June 16, 1924	June 23 1924
Pool 1	New York	$2.90	$2.90
Smokeless	Columbus	2.45	2.35
Clearfield	Boston	2.35	2.40
Somerset	Boston	2.50	2.50
Kanawha	Columbus	..	..
Hocking	Columbus	1.85	1.85
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.65	1.75
S. E. Ky.	Louisville	1.75	1.75
Big Seam	Birmingham	2.00	2.10

FUEL OIL

New York—July 2, light oil, tank-car lots, 28@34 deg. Baumé, 5½c. per gal., 36@40 deg. 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis—June 24, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.50@$1.55 per bbl.; 26@28 deg., $1.55@$1.60 per bbl.; 28@30 deg., $1.60@$1.65 per bbl.; 32@36 deg., gas oil, 4¾@5c. per gal.; 38@40 deg. 5¾@6c. per gal.

Pittsburgh—June 26, f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5⅝c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—June 27, f.o.b. local refinery, 26@30 deg., $1.30@$1.35 per bbl.

Philadelphia—June 27, 28@30 deg., $2.10@$2.163 per bbl.; 18@22 deg., $2.10@$2.16½; 13@16 deg., $1.78½@$1.848 per bbl.

Boston—June 25, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¾c. per gal., light oil, 28@32 deg., Baumé, 6¾c. per gal.

Cincinnati—June 23, tank-car lots, f.o.b. local refinery, 24@26 deg., Baumé, 4⅞c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5⅝c. per gal.

New Plant Construction

Argentina, Rosario—The American Consulate, Vice-Consul H. C. Moses, has received an inquiry for air compressors and solicits catalogs and information from American manufacturers.

Ark., Conway—The Common Council is said to be planning for centrifugal pumping equipment in connection with a proposed water-works plant. A bond issue of $78,000, has been sold.

Ark., Little Rock—The Arkansas Central Power Co. has issued bonds for $1,000,000, a portion of the fund to be used for extensions and improvements in power plants and system.

Ark., Little Rock—J. H. Leveck & Son are considering a boiler house at their mechanical laundry plant. Plans will soon be drawn. It will cost $35,000.

Ark., Norfolk—The W. D. Torrence Lumber Co. contemplates a boiler plant at its lumber mill. A tract of hardwood property has been acquired on the White River.

B. C., Prince Rupert—The Manitoba Pulp & Paper Co. plans a steam-electric plant at its pulp mill at St. Boniface, now under consideration. The entire project will involve $2,500,000.

Calif., Carmichael—The Carmichael Irrigation District has plans for a new pumping plant. It is proposed to install electrically-operated pumps. Bids will soon be asked.

Calif., Del Mar—The Crown Land Co. plans for a pumping plant for booster service in connection with a local waterworks. It is expected to install electric-operated units. Robert F. Cowles, 740 South Broadway, Los Angeles, engineer.

Calif., El Centro—The Pacific Portland Cement Co., Consolidated, Pacific Bldg., is reported to be planning for a steam plant at its properties, consisting of a tract heretofore held by the Imperial Gypsum Co. The station will be used in connection with development for which a sum of $500,000, is being arranged.

Calif., Modesto—The City Council has adopted an ordinance authorizing extensions at the municipal waterworks, including pumping plant and equipment, type of units to be decided. Plans will soon be drawn. F. W. McCarton is city engineer.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., has applied for permission to construct and operate a hydro-electric plant and system in Nevada and Placer Counties, in connection with an irrigation works. The entire project will involve $8,000,000, and will be carried out in conjunction with the Nevada Irrigation District.

Conn., New Britain—Bids will be asked at once for the erection of the proposed boiler plant at the local state normal school. W. F. Brooks, Hartford, Conn., is architect for the State Board of Education. Alfred S. Kellogg, 89 Franklin St., Boston, Mass., is engineer.

D. C., Washington—Bids will be received by the general purchasing officer, Panama Canal, until July 11, for 8 cylinder valves, 4 flue expanders and other equipment, as per Panama Circular 2355.

Fla., Miami—The Miami Fish & Ice Co., recently organized, plans for an ice and cold storage plant, for which a list of equipment will be arranged soon. John T. Wisdom, president.

Fla., Miami—The Seybold Baking Co. plans for automatic ovens, conveying equipment and steam equipment in the proposed addition to its baking plant. The machinery installation is estimated to cost $35,000.

Fla., Miami Beach—The Miami Beach Electric Co. plans for an addition at its steam plant, to cost $80,000.

Fla., Orlando—The Florida Refrigeration Co., recently formed, has tentative plans for an ice-manufacturing and refrigerating plant. A. J. Nye, Orlando, president.

Fla. Seebreeze—The Daytona Public Service Co., Daytona, Fla., plans for a power plant, with installation of a 2,500 kw. turbo-generator and auxiliary equipment. The company will also enlarge its ice-manufacturing plant, increasing the capacity from 50 to 100 tons per day.

Ga., Atlanta—The Georgia Railway & Power Co. has made application for permission to dispose of a bond issue of $3,000,000, the proceeds to be used for hydro-electric power development on the Tallulah and Tugalo Rivers. Preliminary plans are now in progress.

Ga., College Park—The Common Council contemplates centrifugal pumping equipment for its proposed waterworks and sewerage system. Bonds for $73,000 have been issued.

Hawaii, Pearl Harbor—The Bureau of Yards and Docks, Navy Department, Washington, D. C., will take bids until August 13, for one 750,000 gal. elevated steel water tank on steel tower for the local naval operating base, as set forth in Specification 4992.

Ill, Chicago—The Union Pacific Railroad Co., 58 East Washington St., has arranged a fund of $1,204,288, for water and fuel distributing and storage plants at different points along its lines, to be carried out in connection with an expansion and improvement program during 1924.

Ill., Peoria—The Central Illinois Light Co. has issued bonds for $933,000, a portion to be used for power plant and system expansion. R. S. Wallace is vice-president.

Ill., Winnetka—The North Shore Laundry, 806 Elm St., contemplates a boiler plant at its mechanical laundry at Chestnut and Spruce Sts. Plans are being drawn by Otis & Fuller, 6 North Michigan Ave., Chicago, architects. The plant will cost about $55,000.

Ind., Bluffton—The Board of County Commissioners, Court House, will take bids until July 12 for two horizontal return tubular boilers, with accessory apparatus, for local service, as per specifications on file.

Ind., Evansville—Plans have been drawn for a refrigerating plant at the Deaconess Hospital, and orders for equipment will be placed at an early date. Harry E. Boyle & Co., Furniture Bldg., architects.

Ind., Indianapolis — The Indianapolis Candy Co., 225-27 East Maryland St., will build a steam power plant at its candy factory at Union and McCarty Sts., with radial brick stack, 3½ ft. dia. and 125 ft. high. The entire project will cost about $100,000. Bids will be asked early in July. The Russell N. Edwards Co., Union Trust Bldg., architect and engineer.

Iowa, Forest City—M. M. Friedman, operating a local produce warehouse, plans for a refrigerating plant. Plans will be prepared soon.

Iowa, Tama—The Common Council is said to be considering centrifugal pumping equipment in connection with proposed extensions and improvements in municipal waterworks, to cost $40,000. Bonds will be arranged.

Kan., Brookville—The Common Council is reported to be planning for centrifugal pumping equipment in connection with a proposed water system. Plans are being drawn by the Ruckel Engineering Co., Interurban Bldg., Hutchinson, Kan., engineer.

Ky., Louisville—The Kentucky Utilities Co., has issued bonds for $4,500,000, a portion to be used for plant and property expansion for increased generating capacity. Harry Reid, president.

La., Houma—The City Council has called a special election July 15, to vote bonds for $100,000, the proceeds to be used for extensions and improvements in the municipal power plant and waterworks.

Md., Annapolis—The supply officer, local navy yard, has been authorized to purchase two d.c. motors, as per Eng. Requisition 107.

Md., Baltimore—Charles M. Brown, secretary, Severn County Club, 108 West Mulberry St., plans for the purchase of a deep well pump, small capacity.

Md., Baltimore—The Maryland Penitentiary, Forest and Eager Sts., has filed plans for extensions and improvements in the steam power house at the institution, including new pipe tunnels, additional equipment, etc. C. L. Painter, 9 North Pleasant St., is mechanical engineer. Col. Claude E. Sweezy is superintendent.

Mass., Boston—The Edison Electric Illuminating Co., 39 Boylston St., will proceed work on the addition, at its steam plant on Glenville Terrace, near Harvard Ave., Allston Station. L. D. Willcutt & Sons Co., 146 Summer St., is the general contractor. The equipment installation will soon be arranged and carried out under company supervision.

Mass., Holyoke—The Holyoke Water Power Co., operating a hydro-electric power plant, plans for an increase in capital from $1,200,000 to $3,000,000, a portion of the proceeds to be used for expansion.

Mass., Hopedale—The Draper Corp., manufacturer of textile machinery, plans for the complete electrification of its plant, replacing steam-operation heretofore used in about two-thirds of the mills. A list of motors and other equipment to be installed will soon be arranged. Central station service will be used. John A. Stevens, 8 Merrimack St., Lowell, Mass., is engineer.

Mich., Detroit—The Detroit, Toledo & Ironton Railroad, owned and operated by Henry Ford, is reported to be planning for a central generating plant, type to be decided, in connection with the proposed electrification of its lines.

Mich., Lansing—The Lansing Fuel & Gas Co. contemplates steam power equipment in connection with extensions at its central gas generating works.

Mich., Pontiac—The supervising architect, Treasury Department, Washington, D. C., will receive bids until July 11, for furnishing and installing one horizontal smokeless firebox boiler, and accessory equipment, at the local post office, as per specifications on file.

Minn., Brainerd—The Northern Pacific Railroad Co., Railroad Bldg., St. Paul, has plans and will soon take bids on a steam power plant on local site, to cost $350,000. H. E. Stevens, chief engineer.

Miss., Hazlehurst—The Case Lumber Co. plans for a boiler plant at its proposed new lumber mill on land lately acquired. The entire plant will cost $100,000, with equipment.

Miss., Natchez—The Board of Water Commissioners planning for extensions and improvements in the pumping plant at the municipal waterworks, and for the installation of a steel water tank and tower with capacity of 500,000 gal. Bids will be asked for soon. Henry A. Mentz, Magnolia, Miss., engineer.

Mo., St. Louis—The St. Joseph's Academy has purchased a site at Pennsylvania Ave. and Wydown Blvd., totaling 15 acres, for a number of new institutional buildings, including a steam plant and mechanical laundry. The entire project will cost $1,500,000. Albert B. Groves is architect. Rev. P. M. Bradley, Church of the Blessed Sacrament, will be in charge of construction.

Mo., St. Louis—The St. Louis Board of Public Service plans for a refrigerating plant in the union market, for which bids are being received on a general contract until July 22. It is to cost close to $1,000,000.

Nev., Reno—The reclamation service commissioner, Dr. Elwood Mead, has had plans prepared for a pumping plant at Lake Tahoe, consisting of two 55 hp. pumping units, with auxiliary equipment. Robert Allen, Carson City, is state engineer.

N. J., Asbury Park—The Eastern Jersey Power Co. is disposing of a preferred stock issue of $1,250,000, a portion of the fund to be used for extensions and improvements in power plants and system.

N. J., Bridgeton—Work will begin at once on the hospital unit and steam plant for the Board of Trustees, Bridgeton Hospital Association, to cost $400,000. A general building contract has been let to D. A. McClelland, Drexel Bldg., Philadelphia, Pa. Stearns & Woodnutt, Stephen Girard Bldg., Philadelphia, are architects.

N. Y., Brooklyn—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will take bids until July 15, for 600 boiler tubes for the local navy yard, as per Schedule 2385.

N. Y., Lockport—The Niagara, Lockport & Ontario Power Co., is arranging for the purchase of property on the Salmon River, near Orwell, Oswego County, as a site for a hydro-electric power plant, for which it is expected to perfect plans in the near future.

N. Y., New York—A boiler plant will be constructed at the mechanical laundry at 108-10 Bank St., owned and operated by Louis Levy and Jacob Waters, 436 West Forty-first St. Morris Whinston, 116 West Thirty-ninth St., architect.

N. Y., New York—The supply officer, Navy Department, foot of Whitehall St., has been authorized to purchase 312 seamless boiler tubes, as per Y. & D. Requisition 10.

N. Y., Watertown—The Power Corporation of New York, Inc., now acquiring a controlling interest in the Northern New York Utilities, is planning to convert a number of its hydro-mechanical power stations, with total of 37,500 hp., to hydro-electric generating plants, and will increase the capacities. Bonds for $2,000,000 have been issued, to be used in part for property purchases and expansion. J. N. Carlisle is president.

N. C., Oxford—The Board of Commissioners will receive bids until July 10, for an auxiliary pumping plant on the Tar River for the municipal waterworks, including electric-operated pumping units and auxiliary machinery. William C. Olsen, Raleigh, N. C., engineer.

N. C., Taylorville—W. H. Carson, Taylorville, plans for a ice-manufacturing plant, and is interested in receiving information on equipment for a small plant.

Ohio, Dayton—The Dayton Malleable Iron Co. will soon begin a new building at its plant to be equipped for the production of powdered coal for power station service, estimated to cost $45,000, with machinery. The company also plans for the construction of similar plants at its branch works at Ironton, Ohio, and Buffalo, N. Y. Schenck & Williams, Dayton, are architects.

Ohio, Toledo—The Toledo Edison Co. has been granted permission to dispose of preferred stock for $2,267,200, the proceeds to be used for the purchase of the Defiance Gas & Electric Co., Swanton Light & Power Co., and the Holgate Light & Power Co., and for proposed extensions and improvements in present power plants and systems of acquired interests.

Ont., Bala—The Bala Electric Light & Power Co. has filed plans for an addition to its hydro-electric plant, estimated to cost $35,000.

Ont., Huntsville—S. T. Hinton, Huntsville, is said to be planning for a boiler house at his proposed shipbuilding and repair plant.

Ore., Coquille—The Alpine Paper Co. contemplates a boiler plant at its proposed pulp and paper mill. The total cost is estimated at $400,000.

Ore., Eugene — Cogwell Campbell and associates, connected with the Eugene Auto Wrecking & Parts Co., have acquired a site and are considering an ice-manufacturing plant, to cost $30,000. Plans will be prepared soon.

Ore., Linnton—The General Petroleum Co., Higgins Bldg., Los Angeles, Calif., has acquired 7 acres of land, and plans for a storage and distributing works, including pumping station, tanks, etc., estimated to cost $300,000, with equipment.

Pa., Doylestown—The Borough Council, M. S. Cogan, secretary, will receive bids until July 28, for one electric-driven air compressor; electric-operated centrifugal pumping unit; air lift receivers; valves; standpipe, etc., for the municipal waterworks, as per specifications on file. William H. Boardman, 426 Walnut St., Philadelphia, Pa., is engineer.

Pa., Greensburg—The Yukon Coal Co. is said to have plans under advisement for the rebuilding of its coal tipple burned June 24, with loss of $30,000, including equipment.

Pa., Philadelphia—The Kaufman Plush Co., Inc., Mitchell and Rector Sts., has plans for a power house at its mill. The Ballinger Co., Twelfth and Chestnut Sts., is architect.

Pa., Philadelphia—The Manheim Laundry Co., 5344 Germantown Ave., has filed plans for the construction of a boiler plant. Work will begin at once.

Pa., Philadelphia — The supply officer, local navy yard, has been authorized to purchase 40 pressure reducing valves, as specified in Requisition 1033.

S. C., Spartanburg—The Southern Railway, Washington, D. C., has awarded a general contract to Dwight P. Robinson & Co., Inc., 125 East Forty-sixth St., New York, for its car repair shops at Hayne, near Spartanburg. A steam plant will be built. The entire project will involve $2,500,000.

Tex., Clarksville—The Texas Power & Light Co., Dallas, has negotiations in progress for the purchase of the plant and property of the Clarksville Light Co., and plans for extensions and improvements.

Tex., El Paso—The El Paso Electric Co. has arranged for a bond issue of $800,000, a portion of the fund to be used for extensions in power plants and system.

Tex., El Paso—The El Paso Electric Railway Co. is reported to be planning for an addition to its steam plant to double the present capacity. A new turbo-generator and other equipment will be installed. The expansion will cost $500,000.

Tex., Fort Worth — The Southwestern Power & Light Co. is disposing of a preferred stock issue of $2,000,000, a portion of the proceeds to be used for plant and system expansion. A. S. Grenier, president.

Tex., Lufkin—The Common Council contemplates pumping equipment in connection with proposed extensions and improvements in the waterworks. A bond issue of $75,000, is being arranged. Special election will be held July 15.

Tex., San Antonio—The Comal Power Co., recently formed as a subsidiary of the San Antonio Public Service Co., is arranging for the purchase of a site on the Guadalupe River, near New Braunfels, Tex., for a hydro-electric plant. W. B. Tuttle is president of both companies.

Utah, Salt Lake City—The Utah Power & Light Co. has work in progress on a new steam electric plant on the Jordan River, to be equipped for an initial capacity of 50,000 hp.

Va., Blacksburg — The Kinzer Price Mountain Coal Co., recently organized, plans for a boiler plant at its properties. Wirt Dunlap is secretary, in charge.

Va., Norfolk—The Ford Motor Co., Highland Park, Detroit, Mich., has awarded a general contract to the Rust Engineering Co., 311 Ross St., Pittsburgh, Pa., for its local assembling plant, including a steam power plant. All plant equipment will be installed by the owner. The complete works are to cost $2,000,000.

Va., Petersburg—The City Commission plans for the installation of a cold storage plant in the municipal market on Halifax St., in connection with remodeling and improvements in the structure.

Wash., Tacoma—The Municipal Power Bureau has rejected bids recently received for the proposed municipal hydro-electric station at Lake Cushman, and will take new bids for the structure in the near future.

W. Va., Bluefield — The Appalachian Power Co. has issued bonds for $4,000,000, a portion of the proceeds to be used for expansion in plants and properties.

W. Va., Hinton—The Virginian Power Co., Charleston, W. Va., plans for a hydro-electric plant in this section, estimated to cost $800,000, with equipment and transmission lines. The company is operated by Henry L. Doherty & Co., 60 Wall St., New York.

W. Va., St. Albans—The Virginia Tire & Rubber Co., High Lawn, near St. Albans, is said to be planning for a boiler plant at its proposed rubber mill, on site of former plant recently burned. It will cost $75,000. G. C. Hedrick, president.

Wis., Merrill — The Wisconsin Valley Electric Co., Wausau, Wis., has been granted permission by the State Railroad Commission to build a power dam on the Wisconsin River, near Merrill, for hydro-electric power development, the initial installation to total 7,500 hp.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Price declines continue to predominate in the power plant and electrical supplies market. Steel structurals dropped 15c. per 100 lb. at New York warehouses during month. Red and white lead declined ½c. per lb. and quotations are lower on flexible cords, lamps and rubber-covered copper wire. Linseed oil, however, advanced 2c. per gal. in New York and Cleveland. White wiping cloths are up ½c. per lb. at New York washeries.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'e jacket		5¢c. per ft.
Common, 2½-in., 3-ply	80c. per ft. list less	50–10%

Air—Best grade

¾-in., per ft.	3-ply $0 36	4 ply $0.44½

Steam—Discounts from List

First grade 30–5%	Second grade 40–5%	Third grade 50%

RUBBER BELTING—The following discounts from list apply to rubber transmission belting:

Best grade 50%	Second grade 50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING
For cut, bes' grade, 45–5%, 2nd grade, 55%.
For laces in sides, best, 41c. per sq.ft.; 2nd, 37c.
Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.44 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	20.00	14.00
Colored	9@12.50	17.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	16.00	16.00
New York (white, at washeries)	11.25	.....
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.00	$1.09	$0.94

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	14.50	14.50	16.00	16.00
White	14.50	14.50	14.50	14.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50%	60–10%	60%
Tinned	50%	60–10%	4½c. per lb. net

Structural rivets, ½ , ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York $4.00	Chicago $3.75	Pittsburgh $2.60@$2.75

Boiler rivets, same sizes:

New York $4.10	Chicago $3.85	Pittsburgh $3.00

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	41@48
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	36@43
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	17.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	56.00	48@52
(35% tin)	28.00	17.50	23@26

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.40	$4.10	$4.00
Flats, square and hexagons, per 100 lb. base	4.90	4.60	4.50

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¾ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$42.00 (net)	$ 65.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	45%	25%
1,000 to 5,000 ft.	50%	30%
5,000 ft. and over	55%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
½	79.20	84.95	13.00	14.49	8.18	8.78
1	112.06	122.19	19.26	21.46	10.65	11.42
1¼	151.62	165.31	25.65	28.33	14.76	15.78
1½	181.28	197.67	34.19	37.77	18.23	19.47
2	248.90	265.94	62.70	69.24	24.29	25.97
2½	385.50	420.48	102.58	111.33	34.71	37.10
3	504.29	548.81	273.40	302.12	51.66	55.63
3½	633.86	688.65	604.03	667.15	69.41	74.19
4	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$21.00
No. 16 cotton reinforced heavy	24.00
No. 18 cotton reinforced light	17.00
No. 16 cotton reinforced light	20.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.85
0-30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.55	.60	24
40	.27	.32	120	150	.70	.75	24
50	.27	.32	120	200	.95	1.05	24
60	.32	.37	120	300	1.50	1.60	24
				500	2.25	2.40	12
				750	3.75	3.95	8
				1.000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Composition—2 Pc. Plug—Composition	0.8½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York,

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.70	$8.60	$10.65	$16.50
12	9.00	11.50	12.65	22.50
10	11.90	14.80	16.43	28.10
8	16.85	19.45	21.60	37.80
6	.....	.....	30.59	.....
4	.....	.....	42.79	.....
2	.....	.....	61.05	.....
1	.....	.....	80.15	.....
0	.....	.....	108.00	.....
00	.....	.....	125.50	.....
000	.....	.....	152.25	.....
0000	.....	.....	185.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32½%
Standard package	37½%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%